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AN ESSAY
TOWARDS A
SYSTEM OF MINERALOGY.

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TRANSLATED FROM THE ORIGINAL SWEDISH,

WITH ANNOTATIONS, AND AN ADDITIONAL TREATISE ON THE BLOW-PIPE.

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THE SECOND EDITION,

GREATLY ENLARGED AND IMPROVED, BY THE ADDITION OF THE MODERN DISCOVERIES; AND BY A NEW ARRANGEMENT OF THE ARTICLES

BY JOHN HYACINTH DE MAGELLAN,
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IN TWO VOLUMES.

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CLASS III.

Mineral Inflammable Subſtances.

SECT. 228. (144.)

Inflammables. *Phlogiſta Mineralia* [a].

TO this claſs belong all thoſe ſubterraneous bodies that are diſſoluble in oils, but not in water, which they repel; catch flame in the fire; and are electrical.

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[a] Under the claſs of inflammables, are comprized all ſuch minerals as may be deſtroyed by combuſtion, upon the application of a ſtrong heat; and which, in proper circumſtances, emit flame, during the time of combuſtion. *Sulphureous metallic ores*, *pyrites*, and even *metallic ſubſtances*, may be conſidered as an order belonging to this claſs, although they require a ſtill higher degree of heat, to drive off their phlogiſton. The *diamond* and *plumbago* ſeem to be alſo in the ſame caſe. This arrangement, however, would occaſion that confuſion which is meant to be avoided, by the ſyſtematic claſſification given by our Author in Sect. 2. In regard to theſe two laſt ſubſtances, I have retained the *Diamond* among the precious ſtones; and the *Plumbago* follow the Sulphurs in the preſent Claſs. The Molybdena

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It is difficult to determine, what constitutes the difference between the purer sorts of this class;

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lybdena however, that has been reputed formerly as a species of *plumbago*, later experiments have shewn to be of a metallic nature: and of course, it will be ranged in the last Class, after the Semi-metals.

The Noble Author says, that phlogistic substances are *electric (per se)*. It has not, however, that I know, been decided, that all *inflamable minerals* are *electric*, or *non-conductors* of electricity; on the contrary Mr. Kirwan affirms, that fossil coal is not an *electric*.

But, what is the constituent principle by which the minerals, belonging to this Class, become *inflamable?* or rather, what is the nature of these *combustible substances?* what is *combustion*, this common phenomenon so repeatedly beheld, and so little understood, from whence these substances take their denomination? Chemists and Philosophers have given various, and so seemingly opposite theories on this very interesting subject, that it would be impardonable not to give a short account of their ideas, chiefly those of the modern ones, in this edition of a work, whose matter is so intimately connected with these chemical disquisitions.

It was taught by former chemists, that the integrant parts of *combustible bodies* were only *heated*, *burned*, and *reduced into flame*, by the action of *fire*, according to the quantity and condition of the *phlogiston* they contained. This last is what they called the *inflammable principle*, by means of which *combustion* is performed. But Becher, Boyle, Rey, and several other Chemists, admitted that the concourse of *air* is absolutely necessary for the effect of *combustion*. As soon as the various kinds of aeriform-substances began to be known by Modern Philosophers, they soon found, that it is that *kind of air*, discovered by the Father of this new and valuable branch of Natural Philosophy, Dr. Priestley, which he calls *dephlogisticated*, and to which some new Nomenclators give the epithets of *pure*, *vital*, *air of fire* and *empyreal air*, without the interference of which no combustion can take place. It is computed, class; since they all must be tried by fire, in which they all yield the same product; but those

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puted, from many good observations, that among the various component parts of the atmosphere, there is about one-fourth ($\frac{9}{33}$ according to Scheele), or, at least, one-fifth part (according to Mr. Cavendish) of this kind of air, contained therein; and from this circumstance it evidently appears, why by blowing on fire, its violence is proportionably increased.

Mr. Macquer says positively, that *phlogiston* is nothing else but the *elementary fire*, *combined with combustible bodies*; and that the concurrence of *pure air* is absolutely required, for the effect of *combustion*. The manner, however, by which this wonderful, though common, process is really performed, has been the theme of various modern systems.

According to Mr. Lavoisier, *dephlogisticated air* is a *compound* of two substances intimately combined; one is called by him *oxygine principle*, and the other is the *specific elementary fire*. When *sulphur*, *phosphorus*, *inflammable air*, or any other *combustible* body is burned, the *oxygine principle* of the *dephlogisticated* air, says he, combines itself with these bodies, to which it has a strong attraction, and forms new compounds of salts and other bodies (See the latter part of note *a* to Sect. 227): At the same time that the *elementary fire* contained in that air, is set loose, and becomes *sensible*, producing *heat* and *flame*, according to circumstances. In this ethiology the fire produced in *Combustion* does not proceed from the burned body, but from the decomposition of the *dephlogisticated air*, in which it is contained in a *latent* or *insensible state*; while its *oxygine* principle combines itself with *sulphur*, *phosphorus*, or *inflammable air*; and forms *vitriolic* and *phosphoric acids*, or *pure water*.

In the same manner it is pretended, in this theory: 1st, That metals are merely simple substances; 2dly, That *metallic calces* are true compounds formed by the *oxygine* part of *pure air*, with the metallic particles; and 3dly, that *pure water* is a similar *compound* of the same *principle*, with *inflammable air*. Unhappily, however, it happens that this *oxygine* substance cannot be shewn to our senses: nor is it better

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those which in the fire shew their differences by affording

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demonstrated, than the *phlogiston* supposed by the great Stahl and his followers. Mr. Fourcroy has proposed another system after Mr. Lavoisier, which seems less objectionable: he says, that *combustible bodies* are those, which have a strong attraction to unite or *combine* with *pure* or *dephlogisticated* air; and that *combustion* is nothing else but the act of that combination. This assertion is grounded on the following facts: 1st, That a body cannot be burnt without *air*: 2dly, That the purer is this *air*, the more rapid is the *combustion*: 3dly, That in *combustion*, an absorption or waste of *air* is always observed; and 4thly, That the residuum contains often a very sensible quantity of that *pure air*, which it absorbed, and which may sometimes be extracted from it. According to this theory of *combustion*, the objections against the existence of phlogiston, which indeed cannot be demonstrated by an immediate indication to our senses, are intirely avoided. But there are so many phenomena in mineralogy, chemistry, and natural philosophy, which cannot be well understood, nor properly accounted for, without admitting *phlogiston* as a substance, to the presence or absence of which they are adequately attributed, that the *phlogistic principle* cannot be exploded, with propriety, from the theoretic part of Chemistry. *See the note to the following Section about the existence of* Phlogiston.

Long before Messieurs Lavoisier and Fourcroy communicated their doctrine of *combustion* to the public, the *Treatise* of Mr. Scheele on *fire* was published, in 1777, at Stockholm, in which this great Chemist discloses his new system on *fire*, *heat*, *light*, and *phlogiston*; these he represents, in such a striking manner, as being different substances, though nearly related to one another, that we should hardly refuse our conviction to his inductions, were they generally supported by facts, and more consonant to our former ideas on a subject so little perceivable by our senses. *Heat*, according to this able Chemist, is a *compound substance*, consisting of *phlogiston* and *empyreal air*. The calces of gold, which can be reduced to a metallic form, by *heat* alone, in a retort, shew that *phlogiston* is contained in *heat*: because it combines with the *calces* to revive fording different substances, are here considered as being

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revive them, and the *dephlogisticated* air is found in the receiver. The precipitate *per se* of Mercury, if revived in the same manner, gives another instance of this truth. If phlogiston alone, says he, could pass through the retort, there would not be found the *empyreal air* in the receiver, and the ignoble metals might be also revived in the same manner.

I do not see, I must confess, that Mr. Scheele has pointed out any reason, why the *ignoble metals* should not be reduced or revived likewise, from their calces, by the *phlogiston*, contained in the *heat* that passes through the retort; and as to the *dephlogisticated air* he speaks of, which is found after the reduction of those *noble metals*, it may have been combined with their calces, before they were put into the retort. Mr. Kirwan, in his Notes to this *Treatise on Fire*, from which this summary view is taken, says, 1st, that in no instance does it appear that phlogiston penetrates through glass, much less a compound of *pure air* and *phlogiston*; and 2dly, that if Mr. Scheele's notions were true, then other metallic calces, or at least black manganese, would be reduced by bare heat; for this calx dephlogisticates nitrous acid, and therefore has a stronger affinity with *phlogiston* than this acid, as Bergman affirms: *heat* therefore ought as well to be *decomposed* by it, as by nitrous acid. This last objection can hardly be answerable but by some unknown property of the manganese, which is no answer at all. But in regard to the first, many combinations are known of two or more substances that pass through bodies, which would stop each before they were combined; and what Mr. Scheele has said on the nature of *light*, seems to prove, that glass is not always quite impervious to *phlogiston*.

Light, according to Scheele, is a compound, containing *phlogiston* and *heat*, from which both may separate themselves in proper circumstances. A solution of silver, by *nitrous acid*, mixed with *chalk*, and exposed to the sun-shine, is revived into a metallic form by the phlogiston of *light*. Nitrous acid also in a glass vessel, receives *phlogiston* from *light*, and becomes of an orange colour; but if the glass be painted black,

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being mixed with heterogeneous bodies: that small

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the acid receives the *heat*, not the *phlogiston*. Even the various coloured rays of light contain unequal shares of phlogiston, since the *violet rays* part more easily with their *phlogiston*, than the other rays, to revive metals. When light is not obstructed in its passage, no heat is perceived; but if stopped in its course, the opposing body receives *heat*, and sometimes *phlogiston*. Light seems therefore to be the matter of *heat* loaded with a superabundant quantity of *phlogiston*. That which comes out from a furnace, produces *heat* on the surrounding bodies, which ascends up with the rarified air: proceeds forwards in straight lines: and may be reflected from polished surfaces, with this peculiarity, that a concave glass-mirror retains the *heat*, whilst it reflects the light; for, although its focus is bright, yet it is not warm. A plane of glass interposed to this light, retains the heat, and becomes *hot*, but lets the light pass through.

Fire is the more or less *heated*, and more or less *luminous* state of bodies, by which they are resolved into their constituent parts, and entirely destroyed. It requires that they be previously *heated* in contact with air; for, to every *combustible body*, a certain quantity of *heat* must be communicated, in order to set it in the fiery commotion.

Combustion is the action of the *heat* penetrating the pores of bodies, and destroying their cohesion; in this case the body parts with its phlogiston, provided there be a substance present, which has a strong attraction to the inflammable principle. If the heating be performed in open air, the empyreal air (which makes one-fourth part of the bulk of the atmosphere), on account of its stronger attraction, unites with the *inflammable principle*, which is thus set at liberty; from this union the *heat* is compounded; and scarcely is this heat generated, when the combustible body is still more expanded by it than in the beginning, and its phlogiston more laid open. The more the heat is increased, the more minute are the particles into which the *combustible body* is dissolved. The *empyreal* air meets more surfaces, consequently comes in contact with more *phlogiston*; and, according to its nature, small quantity of earthy substance, which all phlogista,

ture, forms an union with a greater quantity of it, which causes a radiant heat. At this moment the constituent parts of the combustible body are so much disunited by the still increasing heat, that the empyreal air, continuing to pour upon it in streams, attracts the phlogiston in still greater quantities; and hence the most elastic substance, *Light*, is composed, which, according to the quantity of *combustible matters*, shows various colours.

Such is the abstract of Scheele's new system, taken from that given by Mr. Russel, in his Notes to *Fourcroy's Lectures* of Chemistry, which I compared with the original French translation of the Author, as it is more correct than the English translation of J. R. Foster; and it appeared to me perfectly consonant to the author's ideas. But the only system that I know, which fully and satisfactorily developes these obstruse matters, relating to the nature of *combustible* and *phlogistic processes*, is that given to the public by Dr. Adair Crawford, whose friendship I shall always acknowledge with the highest pleasure. His New Theory was compleated, and put in the hands of the public, before either he, or any other person in England, had the least knowledge of Mr. Scheele's doctrine. I published, in the year 1780, a *small essay* on this subject, containing a sketch of Dr. Crawford's doctrine, reduced into a mathematical form, which is mentioned by the late famous Professor Bergman, in his excellent treatise *de Attractionibus electivis*, and was inserted in *Journal de Physique*, for *May* and *June*, 1781. The following sketch of the part relating to *combustibles*, is the only one that can be allowed to this note.

Dr. Crawford discovered, by the most accurate and nice experiments, that bodies, which contain a large portion of *phlogiston*, possess but a small share of *specific heat* or *fire*; on the contrary, that those with a great share of this last, contain but little *phlogiston*; and finally, those which are deprived of *phlogiston*, increase their capacity for a greater share of *specific fire*. Thus, when regulus of antimony is deprived of its phlogiston, by calcination, which is then called *diaphoretic*, phlogista leave behind in the fire, is not, however, attended to.

SECT.

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retic, it nearly triples its *specific fire*. The same change takes place in the *crocus martis* and in *iron*. This fact is generally true, whatever be the nature of the substance; and even the aeriform ones are in the same case; for phlogisticated air has very little *specific fire: common air* has more of *it*; and *dephlogisticated* air shews a most prodigious quantity of *fire*.

From these facts it is clear, that *phlogiston* and *fire* are distinct and incompatible substances; so that when one enters into the composition of any body, the other of course is expelled from it. Thus metals are calcined in consequence of a double attraction, by which the metal imparts its phlogiston to the air, while the air communicates its fire to the metallic calces; which is further confirmed by the *air* that is found in metallic calces, whose increased weight, by calcination, corresponds to the *air*, that is expelled from them, by their reduction to a metallic form.

All *combustible* bodies are absolutely in the same case. These are substances which contain a large quantity of *phlogiston* in their composition, but loosely adherent to them. *Dephlogisticated air*, which is greatly loaded with *specific fire*, has, at the same time, a strong attraction to *phlogiston*; and, in the act of *combustion*, imparts its fire to the *combustible body*, which is consumed, whilst the air becomes phlogisticated, or loaded with *ph ogiston*. Thus we find that sulphur contaminates the air, when burned, by the *phlogiston* it throws into it, and the produced vitriolic acid, if any, becomes impregnated with the same.

In some cases the most intense heat, or sensible fire, is produced in the combustion; but in others it is very moderate. This variety generally depends from the quantity and quality of the vapours produced by the combustion; when these are very inconsiderable, and the residuum cannot absorb the *fire*, which is emitted by the air, the remainder is precipitated or diffused all around, and produces a very sensible heat. On the contrary, if the vapours are capable of absorbing it, then very little heat is produced. We know by the most cer-

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SECT. 229. (Additional.)

Inflammable Air. Fire Damp. *Aer Inflammabilis*.

This aeriform substance is easily known by its property of inflaming, when mixed with twice or thrice its bulk of common atmospheric air; and it may be safely asserted to be the real phlogiston almost pure [a].

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tain experiments, that, for instance, the vapour of water absorbs about 800 degrees of heat beyond that of its boiling state; from whence it follows, that whenever there is a quantity of watery vapours produced by *combustion*, very little *Sensible fire* must be felt. So when spirits of wine are fired, the sensible heat, which results from the *combustion*, is very inconsiderable, as the greatest part is absorbed by the watery vapours that are then produced; but when the phosphorus of kunkel catches fire, the heat is very strong, there being but a small quantity of acid to carry off the *specific fire* that is set loose. This is the most satisfactory theory of the nature and process of *combustible* bodies, and of their *combustion*, so far as the state of our present knowledge has opened the field of our views into the Operations of Nature. *The Editor.*

[a] The late eminent Philosopher, Professor Bergman, speaking of *phlogiston*, in his admirable Treatise upon Elective Attractions, says, that "the *inflammable air* extracted from metals, contains *phlogiston* almost pure; and that the two celebrated Philosophers, Priestley and Kirwan, seem to have clearly proved the existence of *phlogiston*, both analytically and synthetically: so that, according to him (this last named gentleman), all reasons for doubting are now removed. This phlogistic principle, when in combination, may be let loose by various methods: having recovered its elasticity, and gained an aerial form, by a proper addition of specific heat,

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It is naturally found in subterraneous cavities, in some coal-pits, and other mines; in stagnant waters, in the mud of lakes [b], and other

it receives the name of *inflammable air*." But some French Philosophers, at the head of whom is the famous Mr. Lavoisier, pretend, that there does not exist such a being in Nature, as that called, since the time of Becher and Stahl, by the name of *phlogiston*.

They say that the absorption, or combination of *dephlogisticated air*, with metallic bodies, by the help of fire, and its expulsion or separation from their calces by the same agent, is all that is required both for their *calcination*, and for their *reduction* or *revification*. But there is a vicious circle in this new theory, which easily evinces the fallacy of their argument against the existence of phlogiston. If it be owing to fire, that *pure*, or *dephlogisticated air*, combines with metals to reduce them to the state of *calces*, why do all metallic calces (those of *gold* and *mercury* excepted) require any *phlogistic* or *inflammable substance* to reduce them back to their metallic form? If not, it should naturally follow that the simple expulsion of pure air by fire, without any phlogistic matter being made use of, ought to be fully sufficient to effect that revification. Monsieur de la Metherie, in a letter inserted in the latter part of the *Journal de Physique*, for June 1784, p. 473, has produced various and strong reasons against these new, but feeble, attempts for exploding the existence of Phlogiston; and Mr. Kirwan is now collecting the most convincing facts to set this truth in the most clear light. *See what has been said in the Note to the last* Sect. *on this subject.*

The Editor.

[b] Mr. Volta, professor in the University at Pavia, has discovered a kind of *inflammable* air, which is very common in Nature, and is found in the mud of various ponds and rivulets. When a stick is thrust into the mud of such places, the air rushes up in large bubbles; and may be easily collected by a funnel, held fast by a metallic ring, into the mouth of an inverted glass vessel filled with water, at the end of a stick; in the same manner as Dr. Pearson has proposed to get the medicinal gas of the Buxton water. This kind of inflammable air seems

other places, where animal and vegetable substances have undergone putrefaction, as laystals, old privies, &c. Also on the surface of springs in Persia, Italy, and France, where it seems to be nothing else but the exhalation of petrol.

It is found likewise over the surface of the earth in various places. The *ignis fatuus*, or *jack-lanthorns*, as well as different fiery meteors, owe their existence to this substance; and the *falling stars* seem to be nothing else but so many trains of inflammable air, in the superior parts of the atmosphere, which catching fire by electricity or otherwise, produce that appearance by burning downwards; as is rendered very probable, by the hissing noise that is sometimes very audible at their appearance.

Inflammable air is also artificially produced in great abundance, by the dissolution of *iron* or *zinc*, in almost all known acids (the *nitrous* excepted); by digesting iron in an infusion of galls; by dissolving zinc in the mineral alkali; by combining iron and zinc with volatil alkali; by the calcination of these two metallic sub-stances

seems to be the usual produce of the putrefaction, and compleat decomposition of vegetable substances in water. Its inflammability is greater or more intense than that of *inflammable air*, produced from the solution of iron or zinc in the *vitriolic* acid; for it requires to be mixed with a larger portion of atmospheric air, to produce its greatest explosion by the flame of a candle. Dr. Priestley mentions this discovery of Professor Volta, in his 3d vol. on *various kinds of air*: and Mr. Volta has published, afterwards, a Treatise on this subject in Italian, with an account of his discovery, &c. *Editor.*

ſtances in the fire: and Mr. Kirwan found lately, that an amalgam, made of zinc and mercury, in a cloſe veſſel, after both had been previouſly dried in a ſufficiently ſtrong, and long continued heat, produced a good quantity of *inflammable air*; ſo that the boaſted theory of ſome French philoſophers, who pretend that ſome water is eſſentially neceſſary for the production of *inflammable air*, is evidently falſe [c]. Oils,

[c] When inflammable air and dephlogiſticated air are burned together, water is found to be the reſiduum; as Mr. Volta, many years ago, found often in the experiments made with his new Eudiometer. Meſſ. Cavendiſh, Lavoiſier, Monge, La Place, and Meuſnier, have aſcertained this fact; and that the weight of this water, ſo produced, is nearly the ſame as that of the two burned airs. But neither of theſe gentlemen ever purified the *inflammable* and *dephlogiſticated* air, from the watery vapours they contain: it is theſe laſt, as it ſeems, which produce that water, they find afterwards.

Mr. Cavendiſh ſays, that *pure* or *dephlogiſticated* air, is water deprived of its phlogiſton; and that *water* is *pure air* united with phlogiſton. But Mr. Watt thinks that water is compoſed of *dephlogiſticated* air, and *phlogiſton*, deprived of great part of its *elementary fire*; and that dephlogiſticated air is *water* united to a great quantity of *elementary fire*, and deprived of its phlogiſton.

Mr. Lavoiſier aſſerts, that water is a combination of *pure* and *inflammable air*; ſo that 8686 parts of the firſt, with 1314 of inflamable air, makes 10,000 of water; and that this *inflamable air* is 12 times lighter than *common air*.

But Mr. de la Metherie holds on the contrary, that the water produced by the combuſtion of theſe two airs, is contained in them both. The experiments of the hygrometer, and the deliqueſcence of ſalts, prove, beyond all doubt, that air contains a conſiderable quantity of water: and we know that the mixture of *pure* and *nitrous* air produces *nitrous acid*, which is as *fluid* as water; ſo that *dephlogiſticated air* evidently contains

Oils, bitumens, and charcoal, distilled dry in a retort, or by their digestion on the fire; lime, and even powder of pebbles, digested in the same manner with *marine acid*, or with *marine acid air*, produce also this inflammable substance. Its principal properties are as follow:

1. It is the lightest of all aeriform substances; *viz.* 10, or even more times lighter than common air. Mr. Kirwan collected it very slowly over quick-silver; and found it then 12 times lighter than atmospheric air. On this account, inflammable air has been employed in the new invented aerostates, by the help of which various adventurers have performed aerial voyages with success. But that inflammable vapour, which is formed from vitriolic air, is heavier than common air.
2. It cannot be inflamed without the concurrence of atmospheric air; but when mixed with it, in a due proportion, and set on fire, it explodes with a considerable noise. If the mixture be of *dephlogisticated air*, a detonation is produced as loud, as the report of a pistol [d]; but mixed or combined

tains this fluid in itself; and the experiment of Mr. Kirwan, mentioned above in the text, is a demonstration that there is not need of any water or moisture for the production of *inflammable air*. The Editor.

[d] Inflammable air, on account of its elastic nature, and of its levity, expands itself over a wide space, and may have every particle contiguous to a sufficient quantity of the *dephlogisticated*

combined with *fixt air*, it burns with a blue lambent flame.

3. The flame of a candle, a burning coal, an electric spark, and that produced by the stroke of a flint, with steel, sets it on fire. From whence it is evident, that the idea of employing this last kind of light, in those mines where inflammable air happens to be found, is erroneous; though, as it always occupies the higher part of the subterraneous cavities, on account of its levity, it may happen sometimes to escape the action of the fire.

4. When unmixed and pure, it extinguishes fire.

5. If breathed, it kills animals. Those who pretended to breathe it with impunity, did not previously breathe out, from their lungs, the whole of the common air, that there was before.

6. It has a disagreeable smell, when extracted from metals; if over mercury, the smell is better. That which is found in marshes, smells musty.

7. It is not absorbed by water, at least that which is extracted from metals, over which it may be kept a long time without alteration; but after one or two years, it is no more inflammable.

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phlogisticated air mixed with. In this situation a spark of fire pervades the whole mass at once, and produces that violent explosion. *Editor, from* Russel's notes.

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8. Does not render lime-water turbid by itself; but being inflamed over it, the water is troubled, and deposits some of the chalk it contains.
9. Has no acid qualities.
10. Does not calcine metals; on the contrary, Dr. Priestley has revived some of their calces by the rays of the sun, through a burning lens, in a glass vessel filled with this air, over a bason of mercury.
11. It accelerates vegetation.
12. It hinders putrefaction, though in a degree very inferior to fixed air.
13. It is absorbed by charcoal [e].

Editor, chiefly from Leonhardi, Kirwan, &c.

SECT.

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[e] Inflammable air admits considerable varieties, according to the nature of the substances from which it is produced, and often gives different residuums upon combustion, some of which are of the acid kind. If it is produced from charcoal, it yields *aerial acid*, or *fixt air*: from solutions of metallic substances in the *vitriolic*, *nitrous*, or *marine acids*; it yields these respective acids, as Mr. Lavoisier asserts.

Æther, converted into vapour in a vacuum, gives a permanent elastic vapour, which is *inflammable*. The atmosphere, which floats round the *Fraxinella* (the plant called *dictame blanc*, which grows in the woods of *Languedoc*, *Provence*, *Italy*, &c.) is inflamable from the admixture of its vapours, which seem to be of the nature of an essential oil: so that on approaching the flame of a candle under this plant, in hot weather, it takes fire in an instant; although the essential oil, extracted from this plant by distillation, is not inflamable, on account of the watery particles mixed with it, as Mr. Bomare asserts.

Mr. Scheele is of opinion, that every inflammable air is composed of a very subtile oil. This coincides with the idea entertained

SECT. 230. (Additional.)

Hepatic Air.

This air seems to consist of sulphur, held in solution, in vitriolic or marine air. It is inflammable, when mixed with three quarters of its bulk of common air. Nitre will take up about half the bulk of this air: and when saturated with it, will turn silver black; but if strong dephlogisticated nitrous acid be dropped into this water, the suphur will be precipitated [a].

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entertained, by chymists, of their phlogiston; and is confirmed by the fact, of its being naturally found in those springs from whence issues petrol, whose exhalations are very inflamable.

The residuum, which remains in the atmosphere after the combustion of inflammable air, is extremely noxious to animals. Doctor Priestley takes it to be a combination of *phlogiston* with *pure air*, and, on this account, calls it *phlogisticated air*. But Mr. Lavoisier, on the contrary, thinks this to be a *primitive substance* of an unchangeable nature, and gives it the singular name of *atmospheric mephitis*. The Editor.

[a] The great Swedish Chemist Mr. Scheele, was the first who discovered the existence of this kind of air; and although his Treatise on *Air and Fire* has been published since the year 1777, hardly any other philosopher has carefully examined its singular properties. Mr. Kirwan has, however, applied himself of late to this object; and has communicated to the Royal Society, his various and interesting observations upon it; as these were made on vessels over quicksilver, we may depend on the results, because, if the vessels are over water, this air is in great part absorbed by it; and for this circumstance

One hundred cubic inches of this air, may hold eight grains of sulphur in solution, in the temperature of 60°; and more, if hotter.

Atmospheric air also decomposes hepatic air.

It is found in many mineral waters, and particularly in the hot baths of Aix-la-Chapelle. The

circumstance these results are sometimes different from those of Mr. Senebier, who has wrote on the same subject.

Professor Leonhardy, in his Treatise upon the *Discoveries of various Airs*, points out the most part of the following properties of *hepatic air*.

1. Its smell distinguishes it from any other kind of air, being like the smell of rotten eggs, or the smell of *hepar sulphuris*.
2. Mixed with two-thirds of common or nitrous air, it may be set on fire by the flame of a candle, like the *inflammable air* of the last Section; the vessel is filled with a white thick smoke, which smells like volatil spirit of sulphur; and a white powder is deposited, which consists of sulphur. It detonates with *dephlogisticated air*.
3. It is miscible with water, and communicates to it a flat, but penetrating and very disagreeable flavour.
4. It kills animals, if inclosed therein.
5. It extinguishes also the flame of a candle when immersed in it.
6. Does not change the colour of paper tinged with Fernanbuco wood:
7. But it always turns the tincture of turnsol to red, whatever be the manner by which it had been produced.
8. Mixed with atmospheric air, it phlogisticates it.
9. The vitriolic, marine, and acetous acid, do not precipitate the sulphur from it. But
10. Nitrous acid, and dephlogisticated marine acid, do precipitate the sulphur from it.
11. Tin, bismuth, regulus of antimony, and zinc, are not attacked by this air.

The cause and manner of their containing sulphur, which was long a problem, has at last been happily explained by Mr. Bergman.

It plentifully occurs in the neighbourhood of volcanos, and in several mines. *Kirwan.*

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12. But copper and iron become of a blue colour; lead easily tarnishes, when immersed in it; and mercury becomes black.
13. Water, impregnated with hepatic air, turns silver black; precipitates arsenic, from its solvenr, into a powder resembling orpigment: precipitates zinc from the vitriolic acid: and the solution of corrosive sublimate, into a white powder. The solutions of silver in nitrous acid and of salt of lead, are precipitated of a black colour. The solution of copper, and of the martial vitriol, as well as that of mercury in nitrous acid, are precipitated by the same, of a dark brown colour.
14. This water, so impregnated, dissolves iron filings; and this solution takes a purple colour, if the infusion of galls be added to it. But phlogisticated alkali does not produce any change.
15. It does not precipitate lime from lime-water, unless a very large quantity of this air passes through a small one of water.

Hepatic air is easily obtained by art, from all sorts of liver of sulphur, whether the base be an alkali, an earth, or a metal, if any acid is poured upon it: and the better, if use is made of the marine acid, because it contains phlogiston enough, and does not so strongly attracts that of the *hepar sulphuris*. For this reason the nitrous acid is not fit for this process, as it combines itself with the phlogiston, and produces *nitrous air*. It may also be produced, by distilling a mixture of *sulphur* and *powdered charcoal*; or of sulphur and oil, &c.

According to Mr. Kirwan (in the first part of *Phil. Transf.* for 1786), *hepatic air* consists of *sulphur* alone, kept in an aerial state by the *matter of heat*. It has evidently, though weakly, an acidity of the *vitriolic kind*, as sulphur does; and no *inflammable air* can be extracted from it, unless when produced by those compounds, which afford the same, as *carbonaceous*, and *saccharine compounds*, &c. *The Editor.*

SECT.

SECT. 231. (154.)

Phlogiston combined with Aerial Acid. Black Lead, or *Wadd*. Phlogiston acido aereo ſatiatum. Plumbago, *Lat.* Reiſbley, *Germ.* Blyertz, *Swed.* [a].

. . . . . It is found

b. Of a ſteel-grained and dull texture, *textura chalybea*. It is naturally black; but when rubbed, it gives a dark lead-colour.

c. Of

[a] The Author, and all preceding Mineralogiſts, confounded the *black lead* with *molybdena*, whoſe appearance is nearly the ſame; although, on cloſe examination, the texture of the laſt, which is compoſed of very diſtinct oblong ſcales, eaſily diſtinguiſhes it from the *black lead*. This laſt ſubſtance, having been lately found to be of a metallic nature, will be ranged among the *Semi-metals* in the fourth and laſt Claſs of Minerals.

The black-lead, or plumbago, is a foſſil ſubſtance extremely black; but when freſh cut it appears of a bluiſh white, and ſhining as lead.

Its texture is micaceous, and minutely ſcaly; pretty brittle; and, when broken, of a granullar and dull appearance.

It leaves a fine blackiſh, ſmooth, and ſhining trace, when rubbed on paper; but of a much darker hue than that made with molybdene, which has a white ſilvering appearance. This eaſily diſtinguiſhes one from the other.

Black-lead is too ſoft to ſtrike fire with ſteel.

 Its

c. Of a fine ſcaly and coarſe-grained texture, *textura micacea et granulata.* Coarſe black-lead.

It has

Its ſpecific gravity is from 1,987 to 2,267. Briſſon found it to be=2,1456.

Is insoluble in the mineral acids.

In a ſtrong heat and open fire it is wholly volatile, leaving only a little *iron*, which ſeems to be accidentally found in it, and a few grains of ſiliceous earth.

The uſual fluxes do not effect its fuſion.

It is decompoſed by detonnation with nitre, in a red hot crucible.

Mr. Scheele found that plumbago conſiſts of phlogiſton combined with *aerial acid.* But Mr. Pelletier has demonſtrated, that, when it is pure, it neither produces any *fixed* or *inflamable air*; both which, when found, are entirely owing to the ſubſtances that are mixed with it.

One part of *plumbago*, according to Mr. Scheele, requires ten of nitre to decompoſe it, whereas one of *charcoal* requires five of *nitre*; hence it appears to contain twice as much phlogiſton as charcoal does.

From hence Mr. Kirwan deduces, that 100 parts of plumbago contain 67 of phlogiſton; for 100 *gr.* of nitre contain 33 *gr.* of real *nitrous acid*; theſe are decompoſed, when it receives as much phlogiſton as is neceſſary to convert it into *nitrous acid*, or a little more. Now 33 *gr.* of nitrous acid are converted into *nitrous air* by 67 *gr.* of phlogiſton; then 100 *gr.* of nitre require, for their decompoſition, 67 *gr.* of phlogiſton. The remaining 33 *parts* may be water, or other volatile ſubſtance. For, according to Meſſieurs Gahn and Hielm, 100 *gr.* of plumbago, calcined in a muffle, did looſe 90 *gr.* in weight, the remainder was a ferrugineous earth; and the ſulphureous ſmell ſhewed it contained ſome pyrite, which both were accidental to the black-lead. But Mr. Pelletier affirms, that this ſubſtance is volatilized in a ſtrong fire, without producing any air, nor other aeriform ſubſtance: from whence it

It has at the ſame time a ſcaly and a granulated appearance.

From

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it muſt be concluded, that the plumbago analyſed by Mr. Scheele, was not quite pure.

But when this ſubſtance is expoſed in cloſe veſſels, it undergoes a long and ſtrong heat, as charcoal does, without any loſs in its weight,

Our Author (Cronſtedt), has obſerved, in a note to this Section, that " Profeſſor Pott had examined the black lead " in covered veſſels, and Mr. Quiſt, in an open fire: from " which difference in the method of treating it, different " notions have ariſen: becauſe the black-lead is nearly unal- " terable when expoſed to the fire in covered veſſels, or when " immediately put into a ſtrong charcoal fire, but it is almoſt " wholly volatile in a calcining heat. This is the caſe with " ſeveral others of the mineral phlogiſtons; and from this we " may in general learn, how neceſſary it is to examine the " mineral bodies by many and different methods; and to en- " deavour to multiply the experiments more, than what has " been hitherto done."

Mr. Pelletier aſſerts, that metallic calces cannot be reduced with it alone, unleſs mixed with *fixed alkaly*, in the ſame manner as when charcoal is employed in ſuch circumſtances.

Nor can it be combined with iron, as Bergman aſſerts, or with any other metal, although it may be ſimply interſperſed between its particles.

Mr. Pelletier acknowledges, that there is a kind of plumbago found ſwimming over the melted iron in large furnaces, where iron-ores are ſmelted. But he thinks that this muſt have been naturally mixed with the mineral; and it is the only known plumbago of a very diſtinct lamellar form, as he obſerved in the pieces got from the iron-works at Vallancy, in the French Province of Berry.

This ſingular foſſil was claſſed alſo among the *inflammables* by Profeſſor Bergman, in his *Sciagraphia*, as well as the *diamond*, on account of their burning in a vehement fire, without leaving any reſiduum. Mr. Kirwan, in his excellent *Elements of Mineralogy*, thought they both

 deſerve

From Gran in the province of Upland, and from Tavastehuslan in Finland [b].

SECT.

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deserved to be treated seperately from any other class of fossil substances, on account of their combustion commencing at so high a degree of heat; but I thought proper to preserve them both, in the classes where our Author had put them at first, as was already mentioned, Note *a*, page 433.

[*b*] Black-lead is found in various parts of the world, though sparingly, and of very different qualities; viz. in *Germany*, *France*, *Spain*, *Cape of Good Hope*, and *America*; but the best sort, which by its fine black and shining substance, is the fittest of all for making good pencils to draw upon paper, is only found in the County of *Cumberland*, in England, at a place called *Borrowdale*, which may be said to furnish the whole continent abroad, as well as at home, with this useful mineral. I have seen various specimens from different countries, but their coarse texture and bad quality, cannot bear any comparison with that of *Borrowdale*, though it sometimes, but seldom, contains pyritaceous particles of iron, &c. It is but a few years ago that this mine seemed to be almost exhausted; but by digging some few yards through the strata underneath, according to the advice of an experienced Miner, whose opinion had been long unattended to, a very thick and rich vein of the best black-lead has been discovered, to the great joy of the proprietors, and advantage of the public.

The great use of plumbago, is to draw the out-lines and sketches of any figure on paper, in the most easy and expeditious manner; and it has the advantage of being taken off at pleasure, by rubbing it off entirely with a piece of that elastic gum or resinous substance, which comes chiefly from Brasil, called by the natives *Caout-chouc*, and known in England, (not many years ago, for this use) by the name of *Indian-rubber*. See the following Sect. 238. on the elastic Petrol.

The plumbago is adapted for this purpose, by being cut into thin parallelopipeds, and put in quadrangular grooves made of cypress-wood; and a slit being glued over, they are worked into small cylinders like quills. This is the true method

SECT. 232. (Additional.)

Mineral tallow. *Sevum minerale. Mumia*, Lat. *Belessoon.*

This was found in the sea on the coasts of Finland, in the year 1736. Its specific gravity is 0,770; whereas that of tallow is 0,969. It burns with a blue flame, and a smell of grease, leaving a black viscid matter, which is with more difficulty consumed.

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method by which the good English pencils are made; whereas the method, indicated by Mr. Fourcroy, of employing the powder of this mineral, made into a paste with sulphur, or mixed with some mucillagenous substance, is never employed but by some poor Jews, who sell these pencils very cheap for carpenters work, and other coarse drawings.

One part of plumbago, with three of clay, and some cows hair, makes an excellent plaster for covering retorts in chemical laboratories, as it keeps the same form, even after they happen to melt with the force of fire.

The famous crucibles of Ypsen, are made at Passaw, in Saxony, with plumbago mixed with clay: they are known in England by the name of *Hessian crucibles*; but there is now a manufactory of the same kind at Chelsea, near London, where crucibles are made nearly as good as the foreign ones. The powder of *black-lead* serves also to cover the straps of razors; and it is with it, that cast-iron work, as stoves and the like, receive a shining surface; but an useful application of this stuff, not generally known, is to smooth the surfaces of wood-work, which slide one over the other, such as *wooden-screws*, *packers-presses*, &c. as neither greasy nor oily substances, or any kind of soapy ointments, produce so good an effect on them. *The Editor.*

It is soluble in spirit of wine, only when tartarized: and even then leaves an insoluble residuum; but expressed oils dissolve it when boiling.

It is also found in some rocky parts of Persia, but seems mixed with Petrol, and is there called *Schebennaad*, *Tsienpen*, *Kodreti*.

Mr. Herman, a physician of Strasburg, mentions a spring in the neighbourhood of that city, which contains a substance of this sort diffused through it, which separates on ebullition, and may then be collected.

Thus far Mr. Kirwan, who, with great propriety, inserted this substance in his *Elements of Mineralogy*, among Phlogistic Minerals; but Dr. Lippert was doubtful whether this substance could be classed amongst them, though he has not given any good reason for excluding it.

But that there exists a fat mineral, like *tallow* or *butter*, has been lately proved by the extraction of a greasy substance out of peat in Lancashire, as will be mentioned in Sect. 250. *The Editor.*

SECT.

SECT. 233. (145.)

Ambergris. *Ambra grisea.*

It is commonly reckoned to belong to the mineral kingdom, although it is said to have doubtful marks of its origin [a].

a. It

[a] Ambergrise, according to the assertion of Mr. Aublet, (in his *Histoire de la Guyane*, printed in 1774), is nothing more than the juice of a tree inspissated by evaporation into a concrete form. This tree grows in Guyana, and is called *Cuma*, but has not been investigated by other botanists. When some branches are broken by high winds, a large quantity of the juice comes out: and, if it chances to have time to dry, various masses (some of which had been so large as to weigh 1200 pounds and more), are carried into the rivers by heavy rains, and through them into the sea: afterwards they are either thrown into the shore, or eaten by some fish, chiefly the spermaceti-whale, known by the name of *Physeter-Macro-Cephalus*, among Ictyologists. This kind of whale is very greedy of this gum-resin, and swallows such large quantities, when it meets with it, that they generally become sick; so that those employed in the fishery of these whales, always expect to find some amber, mixed with the excrements and remains of other food, in the bowels of those whales, who are lean. Various authors, among whom is Father Santos, in his *Ethiopia Oriental*, who travelled to various places of the African coast, and Bomare, say, that some species of birds are fond of eating this substance, as well as the whales and other fishes. This accounts very well for the *claws*, *beaks*, *bones*, and *feathers* of *birds*; parts of *vegetables*; *shells* and *bones of fish*, and particularly for the *beaks* of the *cuttle* fish, or *sepia octopedia*, that are sometimes found in the mass of this substance. Dr. Swediar, however, attended only to these last, though

a. It has an agreeable ſmell, chiefly when burnt:

b. Is conſumed in an open fire:

c. Softens in a ſlight degree of warmth, ſo as to ſtick to the teeth, like pitch.

d. It is of a black or grey colour; and of a dull or fine grained texture [*b*].

The

though he had mentioned alſo the other ſubſtances in his paper, inſerted in the *Philoſophical Tranſactions* for 1783, wherein he attempts to eſtabliſh the very erroneous opinion, that the amber is nothing elſe but a preter-naturally hardened dung, or fæces of the *phyſeter whale*. It is not a little ſurpriſing, that both Dr. Withering and Mr. Kirwan have embraced this ill-grounded notion. Certainly they did not read that paper with any ſort of attention, or they would have perceived the futility of his reaſoning.

[*b*] The late Mr. Aublet abovementioned, with whom I was intimately acquainted, gave me ſome ſpecimens of this gum-reſin, which he collected, on the ſpot, from the *cuma tree*, at Guyana. The beſt of theſe I preſented to my late worthy friend Dr. Fothergill, who, for the eminent qualities of his mind, and the benevolence of his heart, will be ever regretted by all that knew him. From the remainder of theſe ſpecimens, I gave the beſt to my worthy friend Dr. Combe, F. R. S.: and the reſt I ſtill keep. It is of a whitiſh brown colour, with a yellowiſh ſhade; it melts and burns like wax on the fire, but it is rather of a more powdery conſiſtency than any amber I have ſeen, probably on account of the improper ſeaſon in which it was collected. The ſingularity of this gumo-reſin is, that it imbibes very ſtrongly the ſmell of the aromatic ſubſtances which ſurround it; and it is well known, that perfumers avail themſelves very conſiderably of this advantage. My late friend, Mr. Rouelle, one of the greateſt chemiſts of France, examined very carefully, this ſubſtance brought over by Mr. Aublet: and found that it produced the very ſame reſults as any other good kind of amber. Beſides Mr. Aublet's authority, which is deciſive, as being grounded

The grey is reckoned the best, and is sold very dear. This drug is brought to Europe from the Indies. It is employed in medicine: and also as a perfume [c].

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grounded upon direct proofs of fact, Rumphius, quoted by Bergman, long since mentioned a tree, called *Nanarium*, whose inspissated juice resembles amber. It cannot therefore at present be doubted that the origin of this phlogistic substance is the vegetable kingdom; although it may be often found and reputed, as a product of the fossil kind.

This substance, being analysed by Messrs. Geofroy and Newman, quoted by Mr. Fourcroy, yielded them the same principles, as the bitumens; *viz.* an acid spirit, a concrete acid salt, some oil, and a charry residuum; which evidently evinces, I think, that all these fat and oily fossil substances, have their origin from the other two kingdoms of Nature. *The Editor.*

[c] Ambergrise is not only brought from the East Indies, but from the coasts of the Bahama Islands, Brasil, Madagascar, Africa, China, Japan, the Molucca Islands, the coasts of Coromandel, Sumatra, &c. Dr. Lippert, in the Treatise he published at Vienna, in 1782, entitled *Phlogistologia Mineralis*, has copied chiefly from Wallerius what he asserts of this substance. He affirms that there are eight known species of amber, five of a single colour; *viz.* the white and the black from the Island of Nicobar, in the Gulph of Bengal, the ash coloured, the yellow, and the blackish; and two variegated; *viz.* the grey coloured with black specks, and the grey with yellow specks. This last he asserts to be the most esteemed on account of its very fragrant smell, and to come from the South coast of Africa and Madagascar, as well as from Sumatra; and that the black dark coloured amber is often found in the bowels of the cetaceous fishes. The same author adds also from Wallerius, that by distilling the oil of yellow amber (succinum) with three parts and a half of fuming nitrous acid, a residuum remains like rosin, which emits a perfect smell of musk; from whence some conclude, that the ambergrise belongs to the fossil kind: the contrary, however, is evinced in the preceding Note. *The Editor.*

SECT. 234. (146.)

Amber. *Ambra flava. Succinum. Electrum:* Lat. *Carabé*, French. *Agtstein*, *Bernstein*, Germ.

This is a substance which is dug out of the earth, and found on the sea-coasts. According to the experiments of Mr. Bourdelin, it consists of an inflammable substance, united with the acid of common salt, which seems to have given it its hardness [a].

It

[a] The yellow amber, or *carabé*, as the French call it, is a hard, brittle, tasteless substance.

Its specific gravity is from 1065 to 1100.

Its fracture is even, smooth, and glossy, capable of a fine polish; and

Becomes electric by friction.

When rubbed or heated, it emits a peculiar agreeable smell, particularly when it melts, for which effect it requires a heat of 550 degrees of Fahrenheit's thermometer, but it then loses its transparency.

Projected on burning coals, it burns with a whitish flame and a whitish yellow smoke; it gives very little soot, and leaves brownish ashes.

It is insoluble in water or spirit of wine; though this latter, when rectified, extracts from it a reddish colour.

It is soluble in the vitriolic acid, which then acquires a reddish-purple colour; and may be precipitated by water. No other acid dissolves it.

Nor is it soluble in fixed alkalis, nor in essential or expressed oils, without some decomposition, and a long digestion.

But balsams dissolve it readily.

73 gr.

It is supposed to be of vegetable origin, since it is said to be found together with wood in the earth.

By distillation it yields water, oil, and a volatile acid salt, which the above-mentioned author has thought to be the acid of common salt, united with a small portion of phlogiston.

Insects,

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75 gr. of this substance neutralize 100 gr. of nitrous acid; and of course, 100 gr. of yellow amber contain nearly 90 of phlogiston.

By distillation it affords a small quantity of water, an oil of the nature of petrol, and the peculiar acid called the *succineous*, already mentioned in Sect. 166.

100 grains of amber afford about 72 of petroleum; 4.5 of salt, *viz.* of the succineous acid; the remainder is a fixed matter, and water.

According to Scheele, this amber yields, by distillation, an aqueous acid, which possesses all the qualities of vinegar. If so, it is probably of a vegetable origin. *Kirwan.*

My late friend, Dr. Fothergill, was so persuaded of the truth of this last mentioned opinion concerning the origin of this substance, that he often proposed to the curious, the attempt of hardening various rosins by a long deposition, or long standing, surrounded by acids, in the ground, or in proper vessels. A paper of the Doctor's may be seen in the Philosophical Transactions for 1743, N° 472. on this subject.

This kind of amber, says Mr. Fourcroy, is found in small detached pieces, for the most part under coloured sands, dispersed in beds of pyritaceous earth; and above it is found wood, charged with a blackish bituminous matter. Hence it is strongly supposed, that it is a resinous substance, which has been altered by the vitriolic acid of the pyrites, notwithstanding that we know that acids, when concentrated always blacken, and charry resinous substances. In fact, the chemical analysis of this substance rather confirms that supposition.

The singular opinion of Dr. Girtanner, about the *yellow amber* being produced by a kind of ants, may be seen in *Journal de Physique*, for March 1786, page 227.

The

Insects, fish, and vegetables, are often found included in it, which testify its having once been liquid.

It is more transparent than most of the other bitumens; and is doubtless the substance which first gave rise to *electrical experiments* (on account of the power it possesses of attracting little

The colour, texture, transparency, and opacity of this substance, have shewn some other varieties, besides those mentioned in the text, the principal ones are the following;

6. The yellow opaque *succinum*
7. The coloured *green* or *blue*, by foreign matter
8. The veined succinum

} opaque

9. The white
10. The pale-yellow
11. The cittron-yellow
12. The deep-red

} transparent.

The golden-yellow transparent amber, mentioned by the Author, is what the Antients called *Chrysolectrum:* and the *white opaque* was called *Leucolectrum.*

But we must be cautious about the value of the specimens, remarkable for their colour, size, transparency, and the well-preserved insects they contain internally; since there is a probability of deception, several persons possessing the art of rendering it *transparent*, *coloured*, and of *softning* it, so as to introduce foreign substances, &c. into it at pleasure.

Mr. Fourcroy says, that two pieces of this substance may be united, by applying them to one another, after being wet with *oil of tartar*, and *heated:* and Wallerius mentions, that pieces of yellow amber may be softened, formed into one, and even dissolved by means of oil of *turnep-seed*, in a gentle heat; and that, according to some authors, it may be rendered pure and transparent, by boiling it in *rape-seed-oil*, *linseed oil*, *salt water*, &c.

Mr. Macquer says, that for the purpose of making varnish, this substance must undergo beforehand a previous decomposition tle bits of ſtraw, or of other light ſubſtances, when rubbed).

It's varieties are reckoned from its colour and tranſparency. It is found

A. Opake. *Succinum opacum.*

a. Brown.

b. White.

c. Blackiſh

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tion by torrefaction, in order to be diſſolved by *linſeed-oil*, or *eſſential-oils.*

According to Jaubert (in his Dictionaire des Arts), two ounces of *aloes*, and as many of *carabé*, being well diſſolved with 12 ounces of linſeed-oil, in a glazed earthen pot, untill the whole be uniformely incorporated, makes an excellent varniſh like that of China and Japan. Great care, ſays he, muſt be taken to avoid its catching fire in the proceſs. But I believe the mixture of aloes to be a miſtake; as, upon enquiry, I find no where elſe any mention of *aloes* among the receits or formulas for making varniſhes. Unhappilly this kind of books is never publiſhed by good, practical, and honeſt artiſts, becauſe they in general make a ſecret of their crafts; and of courſe we cannot put any reliance either on ſcribling theoriſts, or on catch-penny publiſhers, who hardly know the names of the things they deſcribe.

Beſides, the making varniſhes with yellow-amber, this ſubſtance was much employed formerly in making various pieces of ornament and jewellery: the beſt pieces were cut, turned, carved, or plained, to make vaſes, heads of canes, colars, bracelets, ſnuff-boxes, beeds, and other ornaments, ſmall fine cheſts, &c. But after diamonds, precious and beautifull hard ſtones were brought to uſe, theſe trinkets are little conſidered in Europe: neverthelefs, they are ſtill ſent to Perſia, China, and to various other Eaſtern nations, who eſteem them ſtill as great rarities.

Mr. Fourcroy quotes Wallerius, ſaying, that the tranſparent lumps of this ſubſtance may be employed for making *microſcopes*, *burning-glaſſes*, *priſms*, &c. But this author mentions no ſuch thing in his edition of 1778: nor could it be preferred

c. Blackish.

B. Transparent. *Succinum diaphanum.*

a. Colourless.

b. Yellow.

The greatest quantity of European amber is found in Prussia; but it is, besides, collected on the sea-coast of the Province of Skone; and at Biorko; in the Lake Malaren, in the Province of Upland; as also in France and in Siberia. It is chiefly employed in medicine, and for making varnishes.

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preferred to glass on any account, except for trying the different refrangibility, and modifications of light. He adds also, a report of the King of Prussia possessing a burning-lens a foot diameter, of this fossil substance; and that in the cabinet of the Duke of Florence, a column of amber was seen, six feet high, and a very beautiful lustre: these both I have no objection to believe, they being rather an object of ostentation and luxury, than of any real usefullness.

The Copal is a substance very similar to yellow amber, although not so hard, and of course it takes a less beautiful polish. Some Mineralogists, among whom is Lehman, reckon it among fossils; but Boch, quoted by Kirwan, has shewn it belongs to the vegetable kingdom.

Its chemical products are for the most part the same as those of the yellow amber; but it does not produce any acid salt.

It is commonly called Gum-Copal, which is a very improper denomination, as it is a true rosin. Mr. de Bomare describes the tree which produces this rosin. It grows in New Spain; and Linnæus speaks of one called by him *Rhus copalinum*, &c. but it is also found on the sea coast, as well as the yellow amber. Some confound the one of these two substances with the other; but it is evident that they are very different. It is generally employed in making varnishes by dissolution in oils, or in camphorated spirits of wine, &c. *The Editor.*

SECT.

SECT. 235. (147.)

Rock-oil. Naphtha [a].

This is an inflammable mineral ſubſtance, or a thin bitumen, of a light brown colour, which cannot be decompoſed; but is often rendered impure by heterogeneous admixtures. By length of time it hardens in the open air, and then reſembles a vegetable reſin; in this ſtate it is of a black colour, whether pure or mixed with other bodies. It is found,

A. Liquid.

1. Naphtha [b].

This is ſaid to be of a very fragrant ſmell [c], tranſparent, extremely inflammable, and attracts

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[a] Phlogiſton occurs alſo in the foſſil kingdom, combined in an oily form, but many ſuppoſe this derived from the vegetable kingdom. *Berg. Sciagr.*

Three varieties of Naphta are known, the *white*, the *reddiſh*, and the *green*, or deep coloured. It is in fact a true petrol, of which the lighteſt, the moſt tranſparent, and moſt inflammable, is diſtinguiſhed by this name of *Naphtha*. Mongez.

[b] It is a fine thin coloured oil. It ſwims on all fluids, and is very volatile. Is not decompoſed by diſtillation; and yet, if long expoſed to the air, it changes colour, thickens, and degenerates into petrol. Its ſpecific gravity is =0,708. *Kirwan* and *Mongez.*

[c] Its ſmell is agreeable enough; but is very different from that of vegetable oils. It diſſolves reſins and balſams, but not *gum-reſins*, nor *claſtic-gum*. It diſſolves in the eſſentia oils of thyme and lavender; but is inſoluble in ſpirit of wine and æther. *Kirwan.*

gold [*d*]. It is collected on the surface of the water in some wells in Persia [*e*].

[*d*] It burns with a bluish yellow flame, and is as inflammable as æther; and, like it, attracts gold from *aqua regia*. *Kirwan*.

[*e*] It issues out of white, yellow, or black clays, in *Persia* and *Media*. *Kirwan*.

The finest naphta is brought from a peninsula in the Caspian Sea, called *Okesra* by Kempfer. It issues out through the earth, into cisterns and wells, purposely excavated for gathering it at *Baku* in Persia.

Different Naphtas are found also in Italy, in the Dutchy of Modena, and in Mount *Ciaro*, twelve leagues from Plaisance.

Most naturalists and chemists ascribe the formation of *Naphta*, *Petrol*, &c. to the decomposition of solid bitumens by the action of subterraneous fires; so that *Naphta* is the lightest oil which fire disengages first: what follows, acquiring colour and consistence, forms the different sorts of *petrol*; and these last, united with some earthy substances, or altered by acids, assume the appearance of *mineral pitch*, *pissasphaltum*, &c. The phænomena, which the distillation of yellow-amber presents, seem to support this opinion, as it really furnishes a kind of *naphtha*: then a *petroleum*, more or less brown: and finally, a black substance, like the *jet*, which, urged by the fire, leaves a brittle and porous matter, &c. They observe further, that Nature presents frequently all kinds of petrol near the same spot, from the lightest naphta to the mineral pitch, as may be observed at Mount *Festin*, in the Dutchy of Modena. But although this opinion be the most plausible, some think that these mineral oils, or bitumens, are formed from the vitriolic acid, and various oily and fat substances of the *vegetable* and *animal* kingdoms, buried under the earth by the ancient convulsions and revolutions of this globe, previous to all historical records of mankind. *The Editor from* Wallerius, Mongez, Kirwan, Fourcroy, *&c.*

SECT.

SECT. 236. (148.)

2. Petrol. *Petroleum*, Lat. *Bergöel, Steinoel*, Germ.

This smells like the oil of amber, though more agreeable; and likewise very readily takes fire. It is collected, in the same manner as the Naphta, from some wells in Italy, and in a deserted mine at Osmundsberget, in the province of Dalarne. At this last-mentioned place, it is found in small hollows in the lime-stone, as resin is in the wood of the pine-tree [a].

SECT.

[a] Doctor Priestley has shewn, in the third volume of his Observations and Experiments on Air, that essential oils, long exposed to the atmosphere, absorb not only the pure part, but also the phlogisticated part of it: an absorption, which must in time produce considerable changes in them. By a process of this sort, naptha is converted into petrol, which is an oil of various degrees of density, according to the time during which it has been exposed to the atmosphere. Petrol is found trickling from rocks, or issuing from the earth, in the Dutchy of Modena, and in various parts of France, Swisserland, Germany, and Scotland, as well as in Asia; also on the surface of the water of different fountains, or mixed with earth and sand, from which it is separated by infusion in water. The thinnest sort possesses the properties of naphtha, though in a less degree. It is rendered finer by distillation with water, and leaves a resinous residuum; and if distilled with a volatile alkali, the alkali acquires the properties of succinated ammoniac, and contains the acid of amber. Some sorts of it, according to Monet, are nearly of the density of nut-oil. It is insoluble in spirit of wine. *Kirwan*.

SECT. 237. (149.)

Maltha. Barbadoes-tar.

Petroleum tenax. Kedria-terrestris, Lat.
Erdepech, Bergtheer, Germ.

B. Thick and pitchy rock-oil.

This resembles soft pitch [a]

It

The distinct character of the petrol, is its thickness, resembling inspissated oil: its smell approaches that of turpentine, or rather oil of amber: its flavour is of a penetrating sharpness; and, when pure, it is lighter than spirit of wine. In process of time it looses its smell and former colour, becoming black and thick.

There are three varieties of Petrol, *viz.*

The yellow, very light and volatile. It is found near Modena in Italy.

The reddish, or yellow-red; some of which is collected near Gabian in Languedoc, and in Alsatia.

And the black, or brown, which is heavier and more common. This is found in England, France, Italy, Germany, Sweden, and in various other places. It generally either runs out from the chinks or gaps of rocks; or is mixed with the earth, and gushing out of it; or swimming on the water of some fountains, &c. *Mongez.*

Dr. Lippert says, that on mixing fuming *nitrous* acid with petrol, a kind of rosin is produced, whose taste is very bitter, but the smell is like that of *musk*; and that the *vitriolic acid* produces with it a still more bitter substance, but without that aromatic smell. *Editor.*

[a] Petroleum, long exposed to the air, forms this substance. It is of a viscid consistency; and of a brown, black, or reddish black colour. Sometimes inodorous, but generally

of

It is found in Mossgrufvan, at Norberg, in the province of Westmanland, and at the Dead Sea in the Holy Land [b].

SECT. 238. (Additional.)

Elastic Petrol.

This is a very singular fossil found of late in England.

By its colour and consistency it exactly resembles the *Indian-rubber*, or the *gum-resin* from the North part of Brasil, called *Caoutchouc*, commonly used for rubbing the traces of *black-lead pencils* from paper, as was mentioned in the Note to *page* 454.

It is of a dark brown colour, almost black; and some is found of a yellowish brown-cast, like the same gum-resin.

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of a more or less disagreeable smell, particularly when burned. It easily melts, and burns with much smoak and soot; and leaves either ashes or a slag, proceeding from the heterogeneous matter it contains.

It is insoluble in spirit of wine.

Contains a portion of the succinous acid; since it gives, with mineral alkali, a bitter salt, more difficultly dissoluble than common salt, and which, being treated with charcoal, will not afford sulphur. *Kirwan.*

[b] It is found in Persia, in the chinks of rocks, and in strata of gypsum and lime-stone; or floating on water; also in *Siberia*, *Germany*, *Switzerland*, in coal-pits: and in *America*. Kirwan.

And also in Colebrookdale in England. *Brun.*

With respect to its elastic consistence, it hardly can be distinguished from it, except in the cohesion of its particles, which is weaker.

It has the same property of rubbing off from paper the traces of black-lead pencils.

It burns likewise with a smoky flame; and also melts into a thick oily fluid; but emits a disagreeable smell, like the *fossil pitch*, or *Barbadoes-tar* of the last Section.

It is found in the same earthy and stony beds as petrol; namely, among spar and lead-ores; and some lumps of this hard substance (*viz.* the *Asphaltum* of the following Section) are found in the same spot along with it.

Some specimens of this fossil are of a cylindrical form, like bits of thin branches or stalks of vegetables, though much more flexible, being perfectly elastic.

Upon the whole, this fossil seems to confirm the opinion already mentioned, Note to page 466, of those Mineralogists, who believe that these oily combustibles derive their origin from the vegetable kingdom. It seems worth trying, whether pieces of Asphaltum, buried in damp beds of sparry rubbish, or other kind of earths, would take the same elastic consistence.

But since many beds of *shells* and other *fossil substances*, both of the *vegetable* and *animal kind*, as impressions of various *plants*, and the remains of various *quadrupedes*, &c. have been found in different parts of the globe, whose individual species undoubtedly exist no longer alive

unless

unlefs in far diftant climates, and in the moft remote countries from the fpot where their exuvia are digged out; why fhould we not allow that this new foffil may be the fame original *elaftic gum*, now growing naturally in *Brazil*, *China*, and other *hot climates*, only altered in its fmell, and in the tenacity of its particles, by the long ftanding during centuries, and even myriades of years, buried in the bowels of the earth?

This elaftic petrol was found in 1785, near *Caftelton*, in the County of *Derbyfhire*, in *England*, but in very inconfiderable quantities, of which I got fome very fmall pieces. *The Editor.*

SECT. 239. (150.)

C. Hardened Rock-oil. Foffil Pitch. *Petroleum induratum. Pix montana.* Lat. *Iudenpech, Berghartz, Steinpech, Erhartete, Bergtheer.* Germ.

1. Pure, *Afphaltum.*

This leaves no afhes or earthy fubftance when it is burnt [a].

---

[a] This is a fmooth, hard, brittle, inodorous, black or brown fubftance. When looked through, in fmall pieces, appears of a deep red colour. It fwims in water.

It breaks with a fmooth fhining furface. Melts eafily: and, when pure, burns without leaving any afhes; but if impure, leaves afhes or a flag.

According to Mr. Monet, it contains fulphur, or at leaft the vitriolic acid.

It is flightly and partially acted on by alcohol and æther.

Kirwan and *Mongez.*

It is found at Finnberget, in the parish of Grythytta, in Westmanland [b].

From this or the preceding substance, it is probable, the asphaltum was prepared that the Egyptians used in embalming their dead bodies, and which is now called *Mummia*.

2. Impure, *Pix montana impura*.

This contains a great quantity of earthy matter, which is left in the retort after distillation, or upon the piece of charcoal, if burnt in an open fire; it coheres like a slag, and is of the colour of black-lead: but in a calcining heat this earth quickly volatilises, so that the nature of it is not yet known [c].

It is found in Mossgrufvan in Norberg, and in Grengierberget, both in the province of Westmanland: and also in other places [d].

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[b] It is found also on the shores of the *Red Sea*, in the Dead Sea, in *Germany*, and *France*. Kirwan.

And it comes likewise from *Porto Principe*, in the island of Cuba. *Brun.*

Is found also in many parts of China: and is employed as a covering to ships by the Arabs and Indians. *Fourcroy.*

[c] The substance which rises, and then falls into the receiver during the distillation of this fossil pitch, is entirely the same as the common natural liquid rock oil of Sect. 148.

The Author.

[d] The *Pissasphaltum* is of a mean consistence, between the *Asphaltum* and the common Petroleum.

It is the very bitumen which is collected in Auvergne in France, in the well called *de la Pege*, near *Clermont-Ferrand*.

Mongez.

SECT. 240. (Additional.)

Jet. *Gagas, Succinum nigrum.* Lat. *Jet,* or *Jayet.* French.

The *jet,* the *lapis obsidianus,* and the *fossil wood,* penetrated by mineral inflammable matter, are often confounded together by Naturalists, on account of their black glossy colour, and some other common properties. But the *lapis obsidianus,* or *galinaceus,* is properly a glassy substance produced by volcanic fires, which must be placed in the Appendix among the volcanic productions, as well as the *fossil-wood* described by our Author in his Sect. 285.

As to the jet, it is a very compact bitumen, harder than asphaltum, always black, and susceptible of a good polish. It becomes electrical when rubbed, and attracts light bodies like the yellow amber. It swims on water, and of course its specific gravity must be less than 1000, whilst that of the *lapis obsidianus,* according to Kirwan, is no less than 1744.

It seems to be nothing else than a *black amber,* or *succinum,* but specifically lighter, on account of the greater portion of bitumen that enters into its composition. When burned it emits a bituminous smell.

It is never found in strata, or in continued masses, like the quarries of fossil stones, but in separate

ſeparate and unconnected heaps, or in ſingle pieces like the true yellow amber, deſcribed in Sect. 234. *See* Bomare's Mineralogy, *tom.* 2. p. 435. *Edition of* 1774.

Great quantities of this foſſil have been dug up in the *Pyrenean* mountains; alſo near *Batalha*, a ſmall town in Portugal, where it is called *Azebiche:* and in *Galiza*, a Northern Province of Spain. It is found alſo in Ireland, Sweden, Pruſſia, Germany, and Italy, &c. [*a*].

This foſſil is uſed in making ſmall boxes, buttons, bracelets, and mourning jewels or trinkets. Sometimes it is employed for making black varniſhes with proper oils; and is ſaid, that when powdered, it makes with lime an extraordinary cement, both for hardneſs, duration, and ſolidity, &c.

Editor, from *Kirwan*, *Bomare*, *Lippert*, *Mongez*, &c.

[*a*] Jet ſo much reſembles Cannel-coal in its colour, in its hardneſs, in its receiving poliſh, in its not ſoiling the fingers when rubbed upon it, &c. that many authors confound the two ſubſtances together. Jet, however, when warmed by friction, has the property of attracting bits of ſtraw and other light bodies; but I never obſerved this property in any of the cannel-coals. *Watſon's Eſſays*, vol. III. p. 11

This reſpectable Author might add alſo the other characteriſtic of jet being lighter than water, as Wallerius, Bomare, Mongez, and others aſſert. If ſo, he muſt have been miſinformed by thoſe, who ſay that the cubic foot of jet weighs 1238, or at leaſt 1180 ounces, and that of cannel-coal 1273 ounces, on the ſuppoſition that the cubic foot of water weighs only 1000 ounces. *The Editor.*

SECT. 241. (157.)

Mineral Phlogiston united with earths.
Phlogiston minerale terris imbutum.

A. with calcareous earth. Phlogiston terra calcarea imbutum.

1. With *pure calcareous earth.* This is the *fetid,* or *swine spar* of Sect. 29.

SECT. 242. (157.)

Liver-stone. *Lapis hepaticus.*

B. Mineral phlogiston united with calcareous (argillaceous, ponderous, and siliceous) earth, and vitriolic acid [*a*].

[*a*] This is the *liver stein* of the Swedes, and the *leber stein* of the Germans, already described in Sect. 52. The Noble author said, in that place, that no calcareous earth could be found in this stone, although, when burned, it produced a very good lime. This certainly was a contradiction, arising from the want of a good analysis never having been made before of this substance: but Bergman, in his Sciagraphia, Sect. 90, affirms, that 100 parts of this stone, contain 33 of *siliceous* earth; 29 of caustic *ponderous* earth; almost 5 of *argillaceous* earth, and 3.7 of *lime*, besides the *vitriolic* acid, and the water of crystallization. Mr. Kirwan, however, quotes another analysis of the same Professor Bergman, by which it appears, that 100 parts of the *hepatic stone* contain 33 of *baroselenite*, 38 of *siliceous* earth, 22 of alum, 7 of gypsum, and 5 of mineral oil. *Editor.*

SECT. 243. (158.)

Pitt, or ſtone-coal. *Lithanthrax.*

C. With an argillaceous earth, *Phlogiſton argillâ mixtum.*

1. With a ſmall quantity of argillaceous earth, and vitriolic acid. Coal. *Lithanthrax* [*a*].

It is of a black colour, and of a ſhining texture; it burns, and is moſtly conſumed in the fire; but leaves however a ſmall quantity of aſhes.

a. Solid coal.

b. Slatty coal [*b*].

Found in England, and at Boſerup in the province of Skone.

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[*a*] It is a black, ſolid, compact, brittle, inflammable ſubſtance; of a moderate hardneſs, lamellated texture, more or leſs ſhining, but rarely ſuſceptible of a good poliſh; and does not melt when heated.

According to Kirwan, it conſiſts of petrol, or aſphaltum, intimately mixed with a ſmall proportion of earth, moſtly argillaceous; ſeldom calcareous, and often with pyrites.

Spirit of wine extracts a red colour from it: cauſtic alkali attacks the bituminous part; and fat oils act on it, and form varniſh, at leaſt with ſome ſorts of it. Fixed alkali has never been found in it, nor any ſulphur, except when it contains pyrites.

None of the various kinds of pit-coal are electrics *per ſe*. Kirwan.

[*b*] The varieties of pit-coal are very numerous, according to the proportion of each integrant part of their ſubſtance; but in

SECT. 244. (159.)

2. Culm-coal, called *Kolm* by the Swedes.

This coal has a greater quantity of argillaceous earth and vitriolic acid, and a moderate proportion of petrol.

It

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in regard to their economical uſes, only two varieties are attended to by the Legiſlature of England, eſtabliſhing a difference in the duty payable by *culm*, and *caking coals*; the laſt conſiſt of thoſe coals, that, in burning, ſhew a beginning to melt, ſo far that their ſmalleſt pieces run together, and unite by the adheſion of their ſurfaces: on account of this property it ſeems immaterial of what ſize the pieces are, ſince the ſmalleſt parts coaleſce by fuſion into conſolidated matter; and conſequently, the refuſe or droſs of theſe coals furniſh a fuel fit for the common economical purpoſes of life.

The other ſort of pit-coals, which are indicated by the name of *Culm*, or *Kolm*, in the following Section, do not fuſe, unite, nor cake by the application of heat, but retain their original form, and keep in detached pieces in the midſt of fire. The ſmall of this coal cannot therefore be applied to domeſtic uſe; becauſe, when in powder, this coal-duſt inſinuates itſelf between the crevices, prevents the circulation of air, and choaks up the fire, extinguiſhing it as compleatly as a parcel of imcombuſtible matter. It is the fragments and duſt of this coal which conſtitutes *culm*, and which is only applicable to burn *lime-ſtone* for reducing it to *lime*, and to bake bricks, which are two very valuable articles of public concern.

It ſhould be an eaſy matter for any perſon to diſtinguiſh *culm* from ſmall *caking coal*, either by trying to make fire with it in a common grate, without interpoſing other fuel between it; for if it does, it is a *caking coal*; if not, it is *culm*; otherwiſe, by putting ſome of theſe ſmall fragments of coal on an ignited iron ſhovel; if they melt and run together, they belong

It has the ſame appearance with the preceding one, though of a more dull texture; it burns with a flame, and yet is not conſumed, but leaves behind a ſlag of the ſame bulk or volume as the coal was.

From England, and among the alum rock at Moltorp and Billingen in the province of Weſtergottland [a].

SECT.

belong to the *caking kind:* if not, they are *culm.* But it ſeems that coal-merchants are now in the cuſtom of calling *culm* the powdry parts of pit-coal, of whatever ſort or kind they may happen to be.

There never was any difficulty on the ſubject; and there would be no trouble in collecting the tax, were it not for the inſufferable ignorance and love of deſpotic oppreſſion, which generally pervades the underling officers of the revenue.

Editor, chiefly from Ruſſel's Notes.

[a] Mr. Kirwan has given a deſcription of this kind of coal, extracted from The Memoirs of the Stockholm Academy. Its fracture has a rougher ſurface, than the *cannel-coal* of the following Section 246

Its ſpecific gravity is from 1300 to 1370.

The beſt coal of this ſort affords, by diſtillation, at firſt *fixed air*, then an *acid liquor*, afterwards *inflammable air*, and a *light* oil of the nature of petrol, then a *volatil alkali*; and, laſtly, *pitch-oil.* The reſiduum is nearly three quarters of the whole; and being ſlowly burnt, affords 13 *per cent.* of aſhes, which conſiſt moſtly of argillaceous earth: and about three hundred parts of them are magnetic.

However, according to the analyſis of Mr. Kirwan, 100 parts of this coal contain about 17 of earth, of which 4 are martial; and from hence it appears, that this coal does not conſiſt of a ſhiſtus penetrated with petrol, as ſome have thought, for then a large portion of ſiliceous, magneſian, and calcareous earths, ſhould be found in it.

It

SECT. 245. (160.)

3. Slate-coal [a].

This coal contains abundance of argillaceous earth. It burns with a flame by itself, otherwise it looks like other slates.

It is found at Gullerasen, in the parish of Rettwik, in the province of Dalarne, and also with the coals at Boserup in Skone.

SECT.

It will be necessary to notice here, that coal-merchants in general hardly make any difference in the specific quality of pit-coals, provided they find buyers to dispose of them, and that the duties or taxes be the least possible to pay; so that what is called by them *Culm*-coal, means only the powdry rubbish, or dross of any sort of coals for making lime, or baking bricks, &c. *See Note [b] to the preceding Sect.* 243.
The Editor.

[a] This last mentioned kind has induced me to believe, that the earth of the pit-coals is an argillaceous one, but is not so easy to be discovered after its being burnt. The pit-coals contain more or less of the vitriolic acid, for which reason the smoak, arising from them, attacks silver in the same manner as sulphur does; though the coals be ever so free from marcasite, which however is often found imbedded or mixed with them. *The Author.*

This is undoubtedly the *bituminous schistus*, already described in *Sect.* 148 among the *argillaceous earths.* I have seen, since that Section was printed, aconsiderable quantity of this slaty substance, which was sent from *New Hall*, near *Thirsk* in *Yorkshire*, to Mr. Walker, Lecturer of Natural Philosophy in London.

This

SECT. 246. (Additional.)

4. *Cannel-coal.*

Mr. Kirwan has put together this variety of coal, with that other called *Killkenny*-coal, though they have some different properties.

The *cannel-coal* is of a dull black colour.

Breaks easily in any direction; and, in its fracture, presents a smooth conchoidal surface, if broken transversely.

Contains a considerable quantity of petrol, in a less denser state than other coals.

Burns with a bright lively flame, but is very apt to fly in pieces in the fire. It is said, however, to be entirely deprived of this property by being previously immersed in water for some hours.

Its specific gravity is about 1270.

And being of an uniform hard texture, may be easily turned in the laith, and receive a good polish.

This *schistus* is of a dark bluish rusty colour: when thrown in the fire, burns with a lively flame, and as readily almost as the oily wood of dry *olive-tree*, or *lignum vitæ*; and emits the very disagreeable smell of petrol. Mr. Walker extracted from it, by distillation, as much *liquid petrol*, as nearly its own bulk. I am well informed, that near *Purbeck*, in Dorsetshire, such large quarries of this slate are found, as to afford competent fuel to the poorer part of the inhabitants of that place.

The Editor.

It

It is from this kind of coal that ſmall vaſes, as ink-ſtands, various trinkets, and other curioſities, are made in England, which appear as if made of the fineſt Jet.

Editor, chiefly from *Kirwan*.

SECT. 247. (Additional.)

Kilkenny-Coal.

This coal contains the largeſt proportion of *Petrol* or *Aſphaltum*; burns with leſs flame and ſmoke, and more ſlowly, though intenſely, than the *cannel-coal.*

The quantity of earth in this coal, does not exceed one *twentieth* of its weight.

Its ſpecific gravity is about 1400.

It is frequently mixed with pyrites.

Is found in the County of Kilkenny, belonging to the province of Leinſter, in Ireland. The quality of this coal burning almoſt without ſmoke, is mentioned in a proverb, by which the good qualities of this County are expreſſed. *The Editor, chiefly from Kirwan.*

SECT. 248. (Additional.)

Sulphureous coal.

This conſiſts of the former kinds of coal, mixed with a notable proportion of pyrites:

hence it is apt to moulder and break when exposed to the air.

It contains yellow spots that look like metal:

And burns with a sulphureous smell, leaving either red ashes, or a slag, or both.

Water acts upon it, after it has mouldered.

Its specific gravity is = 1500, or more.

Besides the above varieties, shistus, micaceous shistus, and gneiss, are frequently found in the neighbourhood of coal-mines, so penetrated with petrol, or bitumen, as to constitute an inferior species of coal; but the bitumen being burnt, they preserve their form, and in some measure their hardness.

Also some grey slates, that are so soft as to be scraped with the nail, and are greasy to the touch, burn like coal.

All the differences of coal arise from a mixture of the varieties already mentioned; and

It is observable, that wherever coals exist, slates are generally found near them. Salt, or mineral springs, are also often found in their neighbourhood. *Kirwan.*

SECT. 249. (Additional.)

Bovey Coal. Taub Kohle. Xylanthrax.

This is of a brown, or brownish black colour, and of a yellow laminar texture.

The

The laminae are frequently flexible when firſt dug, though generally they harden when expoſed to the air.

It conſiſts of wood penetrated with petrol or bitumen, and frequently contains *pyrites*, *alum*, and *vitriol*.

Its aſhes afford a ſmall quantity of *fixed alkali*, according to the German chemiſts; but, according to Mr. Mills, they contain none.

By diſtillation it yields an ill ſmelling liquor, mixed with a *volatile alkali* and *oil*, part of which is ſoluble in ſpirit of wine, and part inſoluble, being of a mineral nature.

It is found in England, France, Italy, Swiſſerland, Germany, Ireland, &c. *Kirwan*.

S E C T. 250. (Additional.)

Peat. *Geanthrax*.

There are two ſorts of inflammable ſubſtances known by this name; *viz*.

The firſt of a brown, yellowiſh brown, or black colour, found in mooriſh grounds; in *Scotland*, *Holland*, and *Germany*. When freſh, it is of a viſcid conſiſtence, but hardens by expoſure to the air.

It conſiſts of clay mixed with calcareous earth and pyrites: and ſometimes contains common ſalt.

While ſoft it is formed into oblong pieces for fuel, after the pyritaceous and ſtony matters are ſeparated.

When diſtilled it affords *water*, *acid*, *oil*, and *volatile alkali*.

Its aſhes contain a ſmall proportion of fixed alkali. They are either white or red, according as it contains more or leſs ochre or pyrites.

The ſecond is found near Newbury in Berkſhire. It contains but little earth; but conſiſts chiefly of wood branches, twigs, roots of trees, with leaves, graſs, ſtraw, and weeds.

Kirwan.

SECT. 251. (Additional.)

Stone-Turf.

The Noble Author has ranged the turf among the foſſils of his Appendix; but as that called in England by the name of *ſtone-turf*, contains a conſiderable proportion of peat, it may be mentioned with propriety in this claſs.

Soon after it is dug out from the ground, where it keeps a ſoft conſiſtence, it at firſt hardens; but afterwards it crumbles by long expoſure to the air.

As to the other common turf, it only conſiſts of mould interwoven with the roots of vegetables; but when theſe roots are of the bulbous kind, or in a large proportion, they form the worſt kind of turf.

Although it may appear incredible, it is nevertheleſs a real fact, that in England pit-turf is advantageouſly employed in *Lancaſhire*, to

7 ſmelt

ſmelt the iron-ore of that county. Mr. Wilkinſon, brother-in-law to the celebrated Dr. Prieſtley, and himſelf not leſs famous for his extenſive undertakings in the iron-works, perhaps the greateſt in all Europe, makes uſe of pit-turf in his large ſmelting furnaces of that province. I have ſeen, in the poſſeſſion of Mr. S. More, Secretary to the Society of Arts, a kind of *black tallow*, extracted by the ſame Mr. Wilkinſon, from *pit-turf*. It was very ſoft, and nearly of the ſame conſiſtence as butter. It burned very rapidly with a ſmoaky flame in the fire; but the ſmell was very diſagreeable like that of pit-turf. This confirms the opinion that the tallow deſcribed in Section 232, is probably of a foſſil extraction, as well as the other oils mentioned in the preceding Sections; although the origin of them all may be from the *vegetable* and *animal* kingdoms. *The Editor.*

SECT. 252. (Additional.)

Obſervations on Foſſil-Coals.

Theſe foſſil ſubſtances, which furniſh fuel for the various purpoſes of human life, are diſtinguiſhed by the name of *Coals*, on account of their being a ſuccedaneum for wood and other vegetable productions, which, when dry, or of an oleaginous kind, ſerve for the ſame uſes. If theſe vegetable ſubſtances are deprived of the accefs of air, by covering them after ignition, the half confumed remainder, which is of a black colour, is called by the name of *Coal*, or *Char-coal*; and from hence the foffil, which affords fuel, has alfo been called by the fame name, though of a very different nature.

Pit-coal and *earth-coal* are fynonymous, and mean *coals* dug out of a *pit*, or from the *earth*. But the *lithantrax* denotes *ftone-coal*, and more properly indicates the *Cannel-coal* of Sect. 246; which has the greateft fimilarity to a *ftony fubftance*, by the dull appearance of its fracture, and by the uniform texture of its parts.

All thefe coals are in general a bituminous black, or brown, and dark fubftance [a]: for the

[a] It is known that pit coal, or fea coal, by diftillation, gives out a phlegm, or watery fubftance; then an æthereal or volatile oil; afterwards a volatile alkali; and laftly, a thick and greafy oil. But it is remarkable that by rectifying this laft oil, a tranfparent, thin, and light oil, of a ftraw colour, is produced, which, being expofed to the air, becomes black, like *animal oils*. *Fabroni.*

From this, and other obfervations, the moft general opinion is, that all coals, bitumens, and oily fubftances, found in the mineral kingdom, owe their origin to the animal and vegetable remains buried in the bowels of the earth; fince it is well known, that only organifed bodies have the power of producing oily and fat fubftances. The amazing irregularities, gaps, and breaks of the ftrata of coals, and of other foffil fubftances, evince that this globe has undergone the moft violent convulfions, by which its parts have been broken, detached, and overturned in different ways, burying large tracts of their upper furfaces, with all the animal and vegetable productions where exifting, at the time of thofe horrible cataftrophes, whofe epoch as far precede all human records. And it is eafily to the most part they have a lamellated texture, which breaks easily, and almost always with a shining surface.

The varieties of pit-coals, already mentioned in the foregoing Sections, are the most remarkable, by which they may be distinguished from one another [*b*]. But they are far from being homogeneous in each kind; as the accidental

to be conceived, that the various heaps and congeries of these vegetable and animal substances, remaining for ages and ages in different parts of the bowels of the earth, have obtained various consistences, and still produce those oily and bituminous juices, which find way to gush out, leaving behind their thickest parts on the same places where they are found, and in many others where the industry of mankind never will be able to penetrate. It will be seen by the last Sect. 259. of this Class, that our author inclines very much to this opinion. *See the* feeble arguments *of* Mr. le Camus *to prove the contrary, at page* 178. *of* Journ. de Phys. *for* March, 1779. *The Editor.*

[*b*] Mr. Bertrand, in his Oryctologic Dictionary, reduces all kinds of coals to six general classes, *viz.* 1. *Lithantrax Ligneus.* 2. *Petrosus*: 3 *Terrestris*: 4. *Piceus*: 5. *Fissilis*: 6. *Mineralisatus.* He says, that the *Scotch coals* are heavier, and burn not so well as those of Newcastle; that those of Liege burn quicker, and those from *Brassac*, in Auvergne, and from *la Fosse*, burn with a more agreeable flame, &c. But Mr. Morand, in his *Nomenclature raisonnée*, distributes all sorts of *Pit-coals* into 4 classes: in the first he places 9 varieties, beginning with the *gagas*, *or succinum nigrum*, to the *variegated lithantrax*: in the second, he reckons 7 varieties, beginning with the *Lithantrax eleganti structura*, to that *facie granulata*; and he forms the fourth class with the earthy and poorer kind of fossil coals. He seems, however, to have been puzzled with the slaty coals, as he ranges them in a separate class, perhaps, to shelter himself from the critical objections of those numerous superficial naturalists, who only look for the apparent configuration, without almost any regard to the component parts of fossils. *The Editor.*

qualities, and the various proportions of their component parts, produce a far greater number of properties, which renders them more or less fit for different purposes; though these are generally overlooked, and confounded with the common one of affording fuel for making fire, to warm our rooms, or for culinary operations.

In fact, various kinds of different coals are often found intermixed with one another in the ground. Some of the finer sort run many times in form of veins between the layers of the coarser kind; as I observed in the fine coals, the workmen employed at Birmingham, in a curious manufactory for moulding rods, or canes of transparent and coloured glass, into the required shapes for common buttons, with an astonishing expedition. The fire burned with so clear a flame as I never saw produced by common sea-coal; and I found, upon inquiry, that this particular kind of coal, was picked out from the common coals of that country, it running in particular veins, which the manufacturers know well to be fit for their purpose, though I could not find any distinctive denomination to indicate this specific difference. There is no doubt but a great field both for the theoretic investigation of the nature and original formation of this fossil, as well as for the practical knowledge of the uses to which it may be advantageously employed, remains still unexplored, or at least is yet concealed among few interested practitioners, without affording any extensive advantage to the public.

That

That kind of coal, diſtinguiſhed in London by the name of *Scotch-coals*, produce, when burned, white aſhes and a leſs dirty duſt than the common *Newcaſtle-coals*; though, among theſe laſt, ſome pieces of the Scotch kind are frequently found. On the contrary, thoſe I have ſeen in the fire-places at Wiltſhire, made ſuch a quantity of brown aſhes and dirty duſt, as to ſpoil the furniture in a ſhort time, unleſs proper care was taken to clean the rooms very frequently.

This foſſil bitumen, as Fourcroy remarks, being heated in contact with a body in combuſtion, and a free acceſs of air, kindles the more ſlowly, and with more difficulty, as it is more weighty and compact. When once kindled, it emits a briſk and very durable heat, and burns for a long time before it is conſumed. If extinguiſhed at a proper time, the remaining cinders may ſerve ſeveral times for a new firing, with a ſmall addition of freſh coals. The matter that is burned, and produces the flame, appears very denſe, as if united to another ſubſtance, which retards its deſtruction. Upon burning, it emits a particular ſtrong ſmell, which is not at all ſulphureous, when the earth-coal is pure, and contains no pyrites [c].

When

[c] Hence we ſee how falſe and deceiving are the propoſitions of ſome ignorant pretenders, who boaſt of proceſſes, to deprive pit-coals of ſulphur, as a great improvement to deſtroy the noxious qualities they ſuppoſe ariſing from this kind of fuel. But a general and conſtant experience of the numerous inhabitants of England, and of various other countries on the Continent, as at Liege, part of Holland, and the Auſtrian

When the combuftible, oily, and moft volatile parts, contained in the earth-coal, are diffipated and fet on fire by the firft application of heat; if the combuftion is ftopped, the bitumen retains only the moft fixed and leaft inflammable part of its oil, and is reduced to a true charry ftate, in combination with the earthy and fixed bafe. Pit coals in this charry ftate are called *Coaks*, which are capable of exciting the moft intenfe heat; and are employed all over England in the fmelting of *iron*, *copper*, and other metallic ores to the greateft advantage [*d*].

SECT.

Auftrian Netherlands, where pit coals are the common fuel, evinces the fallacy of their impofition; and to this I may add, the experience of above twenty-two years, during which I have lived in England, without ever finding in myfelf, nor in any of my numerous acquaintance, the leaft alteration in health on this account. *The Editor.*

[*d*] It is well known that the Englifh method of burning *pit coal* into *coak*, has been a moft profitable and happy acquifition, for the fmelting our ores, and for many other metallurgical and chemical proceffes in this ifland. But the ingenious and advantageous undertaking of Lord Dundonal, by which he turns to a very confiderable profit the mines of coals in his and other eftates, building ovens of a proper conftruction to burn *pit coal* into *coak*, and, at the fame time, to collect in feparate receptacles the *volatile alkali*, *oil*, *tar*, and *pitch*, which were generally loft by the ufual method, deferves to be noticed in this place, as it affords a very remarkable inftance of the great loffes to mankind, for want of carefully attending to every refult from great proceffes of art, when made in a large fcale. Thefe ovens are fo contrived as to admit an under fupply of air; and the coals, after

SECT. 253. (151.)

Brimstone. Sulphur.

The Mineral Phlogiston, or Bitumen, united with the vitriolic acid, constitutes *sulphur*, or Brimstone [*a*].

This

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after being kindled, decompose themselves by a slow, but incomplete combustion, which does not destroy the ingredients. The residuum, left in the oven, proves to be the most excellent *cinders* or *coaks*; whilst the volatile parts, which otherwise would be dissipated in the air, are separated and condensed in reservoirs, or receptacles of a capacious size, placed at proper distances beyond the reach of fire.

Monf. Faujas de St. Fond, who visited these works in a trip he made to Scotland, undertook to erect a similar oven of the kind, on his going back to France: and it is rather singular, that he endeavours to establish a claim of having discovered the same processes before he saw them in Scotland; as if it did not reflect a greater honour on his industry, to carry back to his country some useful knowledge in consequence of his travels, than to return as ignorant as our English travellers usually do, whose acquisitions seldom amount to more than the new fashions, effeminate manners, and other silly trifles, which our degenerate Britons are now wont to call refined accomplishments. *The Editor.*

[*a*] This has been the general doctrine of chemists since the time of the famous Stahl, who called, by the name of *Phlogiston*, that very inflammable principle, that had been described by Beccher, under the name of *inflammable earth*. Stahl was the first who discovered the synthetic composition of sulphur, by combining a combustible substance with *vitriolic acid*; and this has afforded the greatest probability,

amounting

This is very common in the earth, and discovers itself in many and various forms. It is found,

A. Native

---

amounting indeed almost to a demonstration, of the truth of his theory. Macquer describes this process, which consists in mixing equal parts of *fixed alkali* and *vitriolated tartar*, with about the fourth part of both of powdered charcoal, in a crucible: the mixture being well stirred with a wooden rod, and the covered crucible placed on the fire for a short time, the matter is poured out, on a greased marble: emits a strong disagreeble smell, like that of rotten eggs: when cold, coagulates, and appears of a dark-red, or liver colour: and is a true *liver of sulphur*. This being dissolved in water, affords a yellowish precipitate on the addition of any acid, which being collected on the filtre, is found to be a true brimstone.

According to this doctrine of Stahl, the *phlogiston* of the charcoal unites with the vitriolic acid of the tartar, or of any other vitriolic compound, and forms sulphur; but, according to the new pneumatic theory, at the head of which is one of the most ingenious chemists of our times, Mr. Lavoisier, the rationale of these phenomena is quite the reverse of what has been asserted by the followers of Stahl. Those bodies which were called *phlogisticated*, are nothing more, according to the new theory, than substances which have a great tendency to unite with *pure air*; a tendency, which in general constitutes *combustibility*. So that whenever Stahl affirms *phlogiston* to be disengaged, as in *combustion* and *calcination*; there is in fact nothing else, say the new theorists, but a real combination of this *pure air*, with some of the component parts of the burned substance, the process being facilitated by the action of *heat*. On the other hand, in all the supposed combinations of phlogiston, a disengagement of air may be often observed to subsist, as is evident in the reduction of metallic calces, and in the decomposition of bodies by the action of acids. In a word, in this pneumatic system, all these compounds of Stahl, as *sulphur* from vitriolic acid, and *metals*, from their *calces*, and *phlogiston*, are only simple substances, which possess a great tendency to unite with *dephlogisticated*

A. Native Sulphur, *Sulphur nativum.*

In this the two constituent parts are mixed in due proportion in regard to each other, according to the rules of that attraction which is between them; it is easily known,

1. By its inflammability, and by its flame [*b*].

2. By

gisticated air. Thus metals unite with the same air on being calcined: and their calces, on being reduced by fire into their metallic state, give out the air they had imbibed before. I must confess that the simplicity of the *Pneumatic Theory* is a great inducement to receive it; but until any *sulphur* can be shown, preexisting in the alkaline base of the *vitriolated tartar* (for the *vitriolic acid* runs off, according to this theory, in the form of *pure air*, to combine with the *charcoal*) no man, in an unprejudiced state of mind, will venture to embrace such a theory. Neither is it at all comprehensible, how the same agent *fire* will produce two opposite effects in similar circumstances; viz. causing pure-air to *unite* with metallic bodies in *calcination:* and to be *separated* from them, when they are revived by the same. *The Editor.*

[*b*] Sulphur evaporates gently at the 170 degree of Fahrenheit's thermometer.

Melts at 185 degrees; and

Flames at 302 degrees of the same thermometer.

Burns with a blue flame, and a disagreeable suffocating smell.

Sublimes in close vessels, without decomposition, except of a small quantity, proportioned to the quantity of air contained in the vessels.

When melted becomes red, but recovers its colour on cooling.

Its constituent parts, viz, the *vitriolic acid* and *phlogiston*, are nearly in the proportion of 3 to 2; for 100 parts of sulphur contain about 60 of this *acid*, and 50 of *Phlogiston.*

It

2. By its smell, when burnt; and,
3. By its producing a liver of sulphur, when mixed with a fixed alkali, like that made from artificial sulphur [c].

It

It is a tasteless, hard, brittle, idioelectric substance, of a yellow greenish colour.

Its specific gravity is from 1900 to 2350.

It is insoluble in water, though, by long trituration, the water seems to take up some part of it; but it seems that it is rather diffused thro', than dissolved in it.

Neither can spirit of wine unite to it, except when both are in a vaporous state; and then 72 parts of spirit of wine take up *one* of sulphur.

Is soluble in hot oils, and also in alkali, both in the dry and liquid way.

Is decomposed by boiling in concentrated nitrous acid; partly decomposed, and partly dissolved by the vitriolic and dephlogisticated nitrous acid. *Kirwan*.

[c] The two pure (caustic) fixed alkalis, *vegetable* and *mineral*, have a very remarkable action on this substance; as, they form true *livers of sulphur*, which are most difficultly decomposed, and the most permanent of all. They may be prepared by the *dry*, or by the *moist* way. In the first process, equal parts of *lapis causticus* and *flowers of sulphur* are fused in a crucible; then run on a marble plate; and, as soon as cooled, are broken into pieces, and kept in a phial with ground stople. But in the *humid way*, the liquor, or lie, of soap-boilers, is heated with a half of its weight of sulphur; till it acquires a deep dark red colour; and is kept, after being filtrated, &c. The difference between these and the common livers, made of mild alkali, is very sensible; these last are of a paler colour, sometimes they are greenish, and always less odorous. It seems that the aerial aid, which they retain, weakens their strength.

The earthy, and saline earthy substances, have no action on the *liver of sulphur*; but the acids precipitate the sulphur in a fine white powder, called the *Magister sulphuris*: and the

gas

It is found

a. Pellucid, of a deep yellow colour;

b. Opake, white, and greyish [*d*].

These

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gas it disengages, is the above mentioned *Hepatic air* of Sect. 230.

Sulphur, nitre, and charcoal, when well mixed together in a proper proportion, form the well-known detonating substance, called *gun-powder*. One hundred pounds of that made at *Essone*, near *Corbeil* in France, contains 75 of nitre, 9 and *a half* of *sulphur*, and 15 of charcoal; but in general one pound of gun-powder contains 12 of nitre, 2 of sulphur, and 3 of charcoal. The opinion of producing, as is pretended, gun-powder without *sulphur*, is quite groundless. The moisture necessary for the powder's assuming the grained form, crystallises the nitre, as may be seen with a magnifier by cutting the grains through. It is owing to the *dephlogisticated air*, disengaged from the nitre, that the combustion of gunpowder is attended with so great a detonation and violence.

The *fulminating powder* is composed of 3 *ounces* of nitre, *two* of dry aerated salt of tartar, and *one* of *sulphur*, well triturated in a warm marble mortar, with a wooden pestle. About a drachm (60 or 72 gr.) of it in an iron ladle, over a gentle fire, detonates with such a report as that of a cannon. Also a mixture of *liver of sulphur*, with the double of *nitre*, detonates with equally as great a report. *Editor from Fourcroy.*

[*d*] *c.* Cristallized, in octoedral prisms, with blunted points.

d. Transparent. Mr. Davila had been informed that this was brought from Normandy in France. *Brun.*

1. Native sulphur is found in different forms, viz. either in solid pieces of indeterminate figure, running in veins through rocks; or in small lumps, in gypsum and lime stones; in considerable quantities at *Solfatara*, and in the neighbourhood of volcanos; or crystalized in pale, transparent, or semitransparent, octogonal, or rhomboidal crystals, in the cavities of quartz; and particularly in the matrices

These are found in Siberia, at Bevieux in Switzerland, and at Solfatara near Naples.

It is often found on lime-ftone, which the vitriolic acid has left untouched, having a ftronger attraction to the phlogifton, and therefore wholly uniting with it.

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matrices of ores: or in the form of fmall needles over hot fprings, or near volcanos. *Kirwan.*

Sometimes it is formed in old privies; of this I faw fome lumps that were found in a very old privy at Paris, *Editor.*

2. United with clay in the aluminous ore of *La Tolfa*, and alfo at *Tarnowitz*, in Silefia. This laft refembles a light grey earth: when dry, burfts, or cracks, in the water, like marl; and poffeffes a ftrong peculiar fmell like camphor. If diftilled, the fulphur fublimes.

100 parts of this earth afford 8 of fulphur, befides gypfum, and a quantity of iron.

3. Mixed with *clay*, iron, and *felenite*. This compound is of a grey, brown, or black colour, found near *Rome*, *Auvergne*, *Spain*, and *Iceland*.
4. With lime-ftone in the form of a *calcareous hepar*. This is found at *Tivoli* near Rome, and elfewhere in Italy. It is fometimes diffolved in mineral waters; *three pounds* of which contain as much as 25 *grains* of fulphur. It often forms incruftations on the brinks of thefe fprings.
5. *In the form of an alkaline hepar*. This is faid to be found in fome waters in Ruffia: of this will be fpoken in Sect. 255.
6. United to Iron and clay of pyrites, &c. of which hereafter, Sect. 254.
7. United to metallic fubftances, as in Sect. 257 and 258. *Editor chiefly from* Kirwan.

SECT. 254. (152)

B. Sulphur that has dissolved, or is saturated with, metals. *Sulphur metallis saturatum* [a].

1. With iron, *Sulphur marti saturatum.*

Pyrites, or Copperas-stone. *Pyrites.*

This is the substance from which most sulphur is prepared, and is therefore ranked here with all its varieties. It is hard, and of a metallic shining colour.

a. Pale yellow Pyrites, *Pyrites subflavus.*

Marcasite.

This is very common, and contains a proportionable quantity of sulphur with respect to the iron; when once thoroughly inflamed, it burns by itself.

1. Of a compact texture, *Texture aequabili,* called *Piedra del Yuca,* in Spain.
2. Steel-grained, *Texture chalybeâ.*
3. Coarse-grained, *Texturâ granulatâ.*
4. Crystallized, *Crystallisatus.*

It shoots mostly into cubical and octahedral figures, though it also crystallizes into innumerable other forms [b].

SECT.

[a] Sulphur is the most common mineralizer of metals, and therefore most of its combinations [illegible] substances, must be ranked among the metallic ores. [illegible]

[b] Of this kind is the [illegible] which should not be thought the same with pyrites, though it comes from the [illegible]

SECT. 255. (153.)

b. Liver-coloured Marcasite, *Pyrites colore rubescente.*

Its colour cannot be described, being betwixt that of the preceding marcasite, and the azure copper ore. When it is of a light colour, it is called in Swedish *Tennbett*, or *Wattnkies*, but *Lefverslag* when it is of a deeper colour. The iron prevails in this kind; it is therefore less fit to have sulphur extracted from it, and also for the smelting of copper ores. It is found

1. Of a compact texture, from Nya Kopparberget, in the province of Westmanland.
2. Steel-grained, from Stollberget in Westmanland.
3. Coarse-grained, from Westersilfverberget in Westmanland.

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same mines. The crystallized or polish-bearing species are known by the name of *marcasites*. In Hungary, there are some which are pretty rich in gold; in the Moder-mine, near Shemnitz, they held sixteen denari. *Brun.*

SECT.

SECT. 256. (155.)

Various Combinations of Sulphur, *with* Iron *and other* Metallic Subſtances.

Sulphur with iron and copper, *yellow* or *marcaſitical copper ore.* (See Sect. 198. *of the Author.)*

Sulphur with iron, ſilver, and lead. *Potters lead ore. (See Sect.* 189. *of the ſame.)*

Sulphur with iron and zinc, *mock lead, black jack,* or *blende. (See Sect.* 229. *of the ſame.)*

Sulphur with iron and arſenic, *arſenical pyrites. (Sect.* 243. *of the ſame.)*

Sulphur with iron and cobalt. *(See Sect.* 250 *of the ſame.)*

Sulphur with iron and biſmuth. *(Sect.* 225. *of the ſame.)*

Sulphur with iron and nickel. *(Sect.* 256. *of the ſame.)*

Sulphur with iron and gold, pyritical gold ore. *(See Sect.* 166. *of the ſame.)*

SECT. 257. (156.)

Other Combinations of Sulphur, *with* Silver, Copper, *and other* Metallic Subſtances.

Sulphur with ſilver, *glaſs ſilver ore* [a]. (*See Sect.* 169. *of the Author.*)

Sulphur with copper, *grey* or *vitreous copper ore.* (*See Sect.* 197. *of the ſame.*)

Sulphur with lead, *Potters lead ore.* (*See Sect.* 187. *of the ſame.*)

Sulphur with biſmuth. (*See Sect.* 224. *of the ſame.*)

Sulphur with quickſilver, *cinnabar.* (*See Sect.* 218. *of the ſame.*)

Sulphur with arſenic, *Orpiment*, *Realgar.* (*See Sect.* 241. *of the ſame.*)

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[a] At *Ramelsberg*, and in the *Hartz*, ſulphur is extracted from the ſulphureous ores of ſilver and lead, mixed with pyrites, by ſublimation, during the terrefáction of theſe ores. This forms *crude ſulphur*, which is purified by a ſecond ſublimation. But in *Bohemia* and *Saxony* it is obtained by immediate diſtillation from pyrites, and afterwards purified by ſublimation in cloſe veſſels. Moſt of the ſulphur uſed here comes from Italy. *Kirwan.*

SECT. 258. (161.)

Mineral Phlogiston mixed with Metallic Earths.
Phlogiston minerale metallis impregnatum.

This is not found in any great quantity.

In regard to its external appearance, it resembles pit coal; and the fat substance contained in it, at times, partly burns to coal, and partly volatilizes in a calcining heat.

The only known varieties of this kind are,

A. Minera cupri phlogistica.

When it has been inflamed, it retains the fire, and at last burns to ashes, out of which pure copper can be smelted. It is found in Sladkierr's Grufva in the province of Dal, and at Bisperg's Klack, in the province of Dalarne.

B. Minera ferri phlogistica.

This is not very different in its appearance from the pit-coal or fossil pitch; but it is somewhat harder to the touch: there are two varieties of this species:

1. Fixt in the fire, *Minera ferri phlogistica fixa.*

Exposed to a calcined heat, it burns with a very languid though quick flame: it preserves its bulk, and loses only a little of its weight. It yields above 30 per cent. of iron.

4. Solid, resembles black sealing-wax.

It is found in the liver-coloured marcasite (Sect. 252), in Waskberget, at Norrberke, in Westmanland.

b. Cracked, and friable, from Finnberget, at Grythyttan, in Westmanland.

2. Volatile in the fire, *Minera ferri phlogistica volatilis.*

This is unalterable in an open fire, either of charcoal in a furnace, or even upon a piece of charcoal with the flame of the blow pipe: but, under a muffel, the greatest part of it volatilizes, so that only a small quantity of calx of iron remains. It is found,

a. Solid, from Kronprint's Shurff, at Kongsberg, in Norway.

b. Cracked, from the parish of Quistbro, in the province of Nerike.

This last kind leaves more ashes: these ashes, when farther exposed to the fire, become first yellowish-green, and afterwards reddish-brown, when, besides iron, they then also discover some marks of copper. It has, however, not been possible to extract any metallic substance from them; the effects of the load stone, and the colour communicated to the glass of borax, having only given occasion to this suspicion.

See the end of Sect. 239. (*or* Sect. 150, *of the* Author.)

SECT.

SECT. 259. (162.)

Obſervation on Bitumens.

That ſubſtance, which the chemiſts call *Phlogiſton*, or an *inflammable principle*, exiſts in moſt of the mineral bodies, though often in ſo ſmall a quantity as not to be perceived; and therefore I have here only enumerated thoſe kinds, in which it exiſts as a principal or very ſenſible character; as, for inſtance, in the fœtid ſpar, or ſwine ſtone.

I do not myſelf know the ſubſtance in its ſimple ſtate, which I call a *mineral phlogiſton* [*a*], ſince the ambergriſe and the rock-oil are nothing elſe than compoſitions which cannot be perfectly decompounded; and are not, beſides, to be extracted from coal, ſulphur, &c. which, notwithſtanding, contain an inflammable ſubſtance. It ſeems as if a great part of this claſs were originally generated from the animal and vegetable kingdoms; ſo that they have been firſt an *humus ater* or mould, with which a vitriolic acid has afterwards been mixed; and that they have been beſt able to retain this phlogiſton, when they have been covered and

[*a*] We may ſay, however, at preſent, that phlogiſton may be produced almoſt pure, after the new obſervations and diſcoveries that have been made of late on the aeriform ſubſtances. *See Note* [*a*] *to Sect.* 229. *Page* 441.

The Editor.

preffed together by another earth; the *coal*, *coal ore*, and *peat turf* (Sect. 193 of the Author), give fome hints or reafons for this fuppofition.

The generation of fulphur and marcafite, requires no phlogifton out of any of the kingdoms of Nature in preference to the other; for the phlogiftons throughout all nature are equally fit to compofe it [*b*].

It is a fublime fubject for philofophers to enquire, how far fire, phlogifton, and electricity, have an affinity with, or dependence on, one another; but as they yet want that light in this matter, which they wifh to have, I hope to be excufed for not mentioning any theories on the fubject.

This clafs is of great ufe in medicine; for inftance, the ambergrife, the falt of the yellow

[*b*] All foffils, containing phlogifton in fuch abundance, that, under proper management, are inflammable, have been referred to this third Clafs of Minerals. The Orders are obvioufly very few; and, accurately fpeaking, there is only one Genus. But fince phlogifton is fo very fubtle, as not by itfelf alone to become the object of our fenfes in its pure ftate, it has been advifable to confider its more fimple combinations as Genera: and this has long been done, fo far as refpects the metals, by univerfal confent.

The name of *Sulphur* may certainly be given to any *acid*, coagulated by *phlogifton* into a folid form; and, if metals confift of certain radical *acids*, faturated with *phlogifton*, as is highly probable, and, with refpect to *arfenic*, and two others, is indubitably proved (See the Note to page 510.), then metals ought to find a place in this Clafs. But until this theory be eftablifhed by numerous experiments, we have only ranked, under this head, the compounds which have not a metallic nature. *The Editor, chiefly from* Bergman's Sciagraphia, Sect. 132. *and following*.

amber, the rock-oil, the asphaltum, and the sulphur. The rock-oil and sulphur are used in fireworks; the asphaltum [c] by the cement-makers, and the yellow amber is used by the varnishers and painters, [d].

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[c] The first English Edition says, that the Asphaltum is made use of by *watch-makers*; but this must be a real mistake, as it is obviously absurd to suppose that any advantage can be reaped from any oily substance, which soon volatilizes, and is even corrosive itself: when the greatest difficulty our watch and chronometer-makers labour under, is to find a very thin and fluid oil, which may be applied to the pivots of the wheels, and to the palets of the escapements, without thickening, nor condensing by cold, nor drying by length of time. Such kind of oil is a great desideratum in watch making, and the asphaltum has quite the opposite qualities. It may, however, be usefully employed in making a durable cement of the best sort, as Bomare asserts. *The Editor.*

[d] The coals in particular are of the greatest consequence for œconomical uses; and happy therefore are those countries which have a sufficient quantity of them; since they may be employed as fuel to almost every purpose, as is plainly proved in England. *Engestrom.*

CLASS

CLASS IV.

Metallic Subſtances.

SECT. 260. (163.)

General Properties of Metals [a].

METALS are thoſe mineral bodies, which, with reſpect to their volume, are the *heavieſt* of all hitherto known bodies. Some

[a] Thoſe metals, which in a calcining-heat loſe their phlogiſton, and conſequently with that the former coherency of their particles, are called *imperfect*, as *tin*, *lead*, *copper*, and *iron*, and all the *ſemi-metals* (of which more hereafter): notwithſtanding which they may be *malleable*. But thoſe which cannot be deſtroyed in the fire alone, are called *perfect*, as *gold*, *ſilver*, and *platina del Pinto*. Neverthelefs, the metals have commonly been conſidered more with regard to their *malleability* than to their *fixity* in the fire, and are there fore divided into;

A. Malleable, which are called *metals*; and

B. Brittle, which are called *ſemi-metals*.

The *zinc* is, however, as a medium between theſe two diviſions, juſt as the *quickſilver* is between the *perfect* and *imperfect* metals; becauſe the *quickſilver* may indeed be ſo far deſtroyed in the fire, that its particles are ſeparated

Some of them are *malleable*; and some may be

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separated during their volatilization; nevertheless, every one of them, even the minutest, retains the phlogiston united with it. *The Author.*

Zinc and arsenic stand also, as it were, upon the borders betwixt *metals* and *inflammables*; for these, in proper circumstances, burn with a very evident flame.

All the metallic substances contain phlogiston, and when, to a certain degree, deprived of it, fall into a powder like an earth; but their attractions for phlogiston are different.

Most of them, when melted in a common way, and exposed to the air, have an earthy crust formed upon the surface, which cannot again be reduced to metal without the addition of some inflammable matter. The *base metals* have this property.

But the *noble metals*, viz. *platina*, *gold*, and *silver*, are so firmly connected to the phlogiston, that they never calcine under fusion, however long continued; and, after being changed into a calx in the liquid way, when melted in the fire, they re-assume their metallic form, without any other phlogiston than what is contained in the matter of heat.

Quicksilver holds a kind of middle place; for, like the *base metals*, it may be calcined, though not readily; and like the *noble* ones, it may be reduced by heat alone.

Bergman's Sciagr.

We may therefore reckon four *noble* or *perfect metals*; viz. *gold*, *platina*, *silver*, and *mercury*; because, when calcined, they recover their phlogiston, without the addition of any phlogistic substance.

But as *tin*, *lead*, *copper*, and *iron*, cannot be reduced without such addition, these are called *Ignoble* and *Imperfect*, or *base metals.*

However, all these eight metals (even mercury, when solid) are *malleable* to a considerable degree, and are called *intire metals*. But

Bismuth, *zinc*, *antimony*, *arsenic*, *cobalt*, *nickel*, *manganese*, *molybdena*, and *wolfram*, are scarce at all malleable, and hence they are called *Semi-metals*. Nevertheless, *zinc* and *purified nickel*, are more malleable than any of the other semi-be *decompounded*; and, in a melting heat, be brought

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semi-metals; so that we have four *perfect* or *noble* metals; four *imperfect* or *base*; eight *intire*; and nine *semi-metals*.
Kirwan.

The various degrees of heat required, to reduce metals to a fluid state, are seen in the following table, which was extracted, for the most part, by Dr. Withering, from the printed Treatises of the late celebrated Professor Bergman. It exhibits, in a simple view: 1. The *specific gravity* of each metal: 2. The *degree of heat* by Fahrenheit's scale, in which it melts: 3. The quantity of *phlogiston* it requires for its saturation: and 4. its *attraction* to the same *saturating phlogiston*. We must, however, observe, that if the second column be compared with that of Wedgwood's thermometer, already mentioned in the Note to page 230 of this Mineralogy, their great disagreements betray some fundamental error in the assumed data; as the degrees of heat, assigned by Mr. Wedgwood, for melting *gold*, *silver*, and *copper*, are more than quadruple of those assigned by Bergman; and that for melting *iron* is more than *eleven* times greater; although they both nearly agree in the *red heat* of *iron*, which Bergman says to be 1050 degrees, and Wedgwood 1077. As far as I can judge, the fault lays in Mortimer's thermometer, which Bergman quotes with some diffidence (Sect. 197. of his *Sciagraphia)*: probably the changes caused by heat, on this metallic thermometer, are in a much less increasing proportion by intense fire, than those indicated by the contraction of the *pure clay*, happily employed by Wedgwood in his thermometer. I have therefore added another column to this table marked *Wedgw.* with the degrees of the melting heats already ascertained by this last thermometer, as being the nearest to truth. The curious may fill up the vacancies whenever they please, as these new thermometers can now be had for three pounds sterl. each, at the Inventor's Ware-house, London.

N. B. Metallic Thermometer of Mr. Crom. Mortimer, is compleatly described by himself, in the vol. of the *Phil. Transact.* for 1747, *p.* 684. *The Editor.*

METALS.

brought back again to their former ſtate, by the

METALS.	Specific Gravity.	Melting Heat. *B.rg.*	Melting Heat. *W.dgw.*	Saturating Phlogiſton.	Attraction to ſaturating Phlogiſton.
Gold	19,640	1301	5237	394	1 or 2
Platina	21,000			756	1 or 2
Silver	10,552	1000	4717	100	3
Quickſilver	14,110	—40	—40	74	4
Lead	11,352	595		43	10
Copper	8,876	1450	4587	312	8
Iron	7,800	1601	17977	342	11
Tin	7,264	415		114	9
Biſmuth	9,670	494		57	7
Nickel common	7,000	1301		156	11
Nickel pure	9,000	1601		109	5
Arſenic	8,308				
Cobalt common	7,700	1450			
Cobalt pure		1601			
Zinc	6,862	699		182	11
Antimony	6,860	809		120	6
Manganeſe	6,850	very great		227	11

N. B. By *ſaturating phlogiſton*, Profeſſor Bergman means to expreſs the proportionate quantities taken away from each metallic ſubſtance, when diſſolved by means of acids, and of courſe reduced to a calciform ſtate. The laſt column only expreſſes their attraction to this part of their phlogiſton, not to that which ſtill remains united to them in a calciform ſtate. *Withering.*

The great ſimilarity between *metallic* and *inflammable* ſubſtances, has been mentioned in Note [*a*], to Sect. 228. p. 433. But metals in general are opake bodies, whoſe ſpecific gravity exceeds 5000, as the lighteſt of them are above ſix times heavier than an equal bulk of diſtilled water. They conſiſt of heavy, dull, brittle earths, combinable with phlogiſton, and whilſt ſo combined, poſſeſſing a ſhining appearance. *Kirwan* and *Bergman.*

Mr. Mongez remarks, that the following are the general properties of metals, when conſidered as *phyſical bodies*; viz. their *opacity*, great *ſpecific gravity*, *ductility*, *tenacity*, *cryſtalization*, *flavour*, and even *ſmell*, at leaſt in ſome of them.

It

the addition of the phlogiston they had lost in

It is from their *density* that their *gravity* and *opacity* proceed; this last being such, that even reduced to the thinnest plates, no rays of light can pass through their particles, unless there remains an interstice, or pore, quite free from the metallic substance. Gold leaf must, however, be excepted, which exhibits a fine green by transmitted light. *See Note* [*d*] *to Sect.* 261.

As to their *crystallization*, it has been found to take place, whenever they are pure, and left to cool very slowly by themselves, after having been perfectly fused. *See* Journal de Physique, *for July* 1781, p. 74. The *flavour* and *smell* abovementioned, are very sensible in the reguline substances of *arsenic* and *antimony*, as well as in *lead*, *copper*, and *iron*. *The Editor.*

All metals are conductors of electricity; and more perfectly so than any other bodies, during their union with phlogiston.

They are soluble either in nitrous acid, and in deplogisticated marine acid, or in *aqua regia*; and are precipitable in some degree by caustic alkalies; and, except platina, by the Prussian alkali.

When dephlogisticated, they communicate a tinge to *borax*, and to *microcosmic* salt, or at least render them *opake*.

They assume a convex surface, when melted; and even a globular form, if in a small quantity; and though they mix, for the most part, with one another, whilst fused, yet they refuse to unite with unmetallic substances, even their own calces, iron only excepted, which does to its own calx *slightly dephlogisticated*, and to *plumbago*. Nickel also, and some others, may contain *sulphur* in their reguline state.

Metals, when calcined, are capable of uniting with other calces and salts.

Three of the metallic calces have been found to be of an acid nature; viz. the *arsenical*, *molybdenic*, and *tungstenic*; from which, by analogy, the nature of other calces may be conjectured.

The phlogiston, contained in metals, is in a pure state; *viz.* without *water* and *aerial acid*, with which it is invariably accompanied in all other compounds, except *acid airs* and *sulphur*. The Editor, chiefly from *Kirwan*.

When

their decompoſition.

When metallic ſubſtances are naturally found in the earth, united to their full ſhare of phlogiſton, and conſequently poſſeſſing their peculiar properties, they are called *native*.

But when they are found more or leſs deprived of their phlogiſton and of their properties, combined with other ſubſtances, they are then called *mineralized*. This is the moſt common ſtate of the mineral kingdom. The ſubſtance ſo combined with them is called the *Mineralizer*; and the whole is called *ore*; by which name are alſo diſtinguiſhed the *earths* and *ſtones*, in which metallic ſubſtances are contained.

But if both metallic ſubſtances are mixed together in their *metallic* or *reguline* form, without the loſs of *phlogiſton*, they are then ſaid to be *alloyed*.

When the *minerallizer* is of a *ſaline nature*, and renders the metallic combination ſoluble in leſs than 20 times its weight of water; the compound is ranged among *ſalts*. Thus the *vitriols* of *iron*, *copper*, and *zinc*, are rather claſſed with *ſalts*, than with *ores*.

The commoneſt mineralizers are *ſulphur*, *arſenic*, and *fixed air* (or *aerial acid*). The leaſt common are the *vitriolic* and the *marine acids*. The *phoſphoric* has been found only in two inſtances; *viz.* united to *lead*, diſcovered by Gahn; and to *iron* in the *ſiderite*, as Mr. Meyer believes.

Thoſe metallic ſubſtances, mineralized by *aerial acid*, are called *Calciform ores*. The Editor, chiefly from *Kirwan*.

If the new doctrine of Mr. Lavoiſier and his followers, who pretend that calces of metals are a compound of *dephlogiſticated*, or *vital air*, with the metallic ſubſtance, were any ways probable; all *calciform ores* ſhould produce this *vital air*, inſtead of *aerial acid*, when they are reduced to their metallic-form, which is not the caſe; neither ſhould all the *baſe metals* and *ſemi-metals*, abſolutely require the mixture of ſome phlogiſtic ſubſtance, for being reduced from the ſtate of calces to their metallic form, which otherwiſe would be quite uſeleſs, if their reduction ſimply conſiſted in their ſeparation from the *vital* (the dephlogiſticated) *air*. See the Note [*a*] to page 442.

The Editor.

ORDER

ORDER THE FIRST.

Noble or Perfect Metals.

SECT. 261. (164.)

Gold, *Aurum: Sol Chymicorum*, Lat. *Or*, French.

THIS ſubſtance is eſteemed by mankind as the principal and firſt among the metals; and that partly for its ſcarcity; but chiefly for its following qualities.

1. It is of a yellow ſhining colour.
2. It is the heavieſt of all known bodies, its ſpecific gravity to water being as 19,640 to 1000.
3. It is the moſt tough and ductile of all metals. One grain of it may be ſtretched out ſo as to cover a ſilver wire of the length of 98 *Swediſh ells*, by which means $\frac{1}{7056000}$ of a grain becomes viſible to the naked eye [a]

4. Its

[a] According to Paucton, 98 Swediſh ells make only 63,66 Engliſh yards, (2291,76 Engliſh inches); but, as the *hundredth part* of one inch is viſible enough to the naked eye; and we may conceive, that every one of theſe minute cylinders can be ſeen by rays of light reflected from ſix different parts, at leaſt, of its ſurface, the Noble Author might ſafely aſſert,

4. Its softness comes nearest to that of lead, and

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assert, that above one millionth part of a *grain* of gold; (*viz.* $\frac{1}{1375056} = \frac{1}{229176 \times 6}$), is visible to the naked eye.

But Wallerius goes still further, unless there be some error in the press; for he says (page 352. vol. II. edit. 1778); *purum etenim aurum pondere unius grani ad* 500 *ulnarum longitudinem extendi posse.*

Halley, quoted by Apligny (p. 152. of his Treatise on Colours), says, that *one ounce* of gold ($=576$ grains) is enough to cover 48 *ounces* of silver, which may be drawn so fine, without leaving the silver naked, that 6 feet of it shall not weigh above *one grain*. Then *one grain* of gold may cover a wire of 294 feet, or 98 yards; and $\frac{1}{10584}$ of one grain, may cover $\frac{1}{3}$ of one inch, which divided into 10 parts, every one of them will be very visible without any magnifier: from thence it is evident, that $\frac{1}{105840}$ of *one grain* of *gold* is very discernible to the naked eye, in each single side of its surface.

Boyle, quoted also by Apligny, says, that one grain and a half of gold, may be beaten into 50 leaves of one inch square; which, if cut by parallel lines, drawn at the distance of $\frac{1}{100}$ of an inch from one another, will produce 25 millions ($25000000 = 5000 \times 5000$) of little squares, very discernible to the naked eye.

The ductility of gold is such, that it may be extended, by the hammer, 159092 times its surface.

I am informed, by an intelligent gold-beater in England, that the finest gold leaf is that made in new skins, and must have an alloy of 3 *grains* of copper to the *ounce troy* of pure gold, or else it would be too soft to pass over the irregularities of the skins. He affirms, that 80 books, or 2000 leaves of gold, each measuring 3,3 square inches; *viz.* each leaf containing 10,89 square inches ($=3,3 \times 3,3$), weigh less than 16 *dwts*, or 384 *gr.* ($=16 \times 24$ *gr.*). Each book, therefore, (or 25 leaves $=272,23$ square inches) weighs less than 4,8 *gr.* ($=\frac{384}{80}$); and each *grain* will produce 56,718 square inches ($=\frac{10,89 \times 25}{4,8\ gr.}$).

and consequently it is but very little elastic [b].

5. It is fixed and unalterable in air, water, and fire, because it does not easily part with its phlogiston; its liquid menstruum (7) being only made by art.

It has, however, according to Homberg's experiments, when exposed to Tschirnhausen's burning-glass, been found partly to volatilise

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Now one cubic inch of pure gold weighs 10,359 *ounces Troy*, or 4972,32 *gr.* (480 × 10,359 *oz*); and of course, *one grain* of gold, when beaten into a square surface of one inch, only occupies, by its thickness, the $\frac{1}{4972,32}$ part of the inch side of this cube; but as each grain produces above 56,718 leaves of this dimension, it is evident that the thickness of each leaf is in fact less than the $\frac{1}{56,718 \times 4972,32}$, or $\frac{1}{282020}$ part of an inch.

By the above treatment, the 16 *dwt.* of gold are made to cover 151,24 *square feet*; since the 16 *dwts*, or 384 *gr.* produce 21779,712 (= 384 × 56,718) square inch leaves, 144 of which make a *foot square*. But, when silver is covered with gold, and drawn into a wire, the gold may spread over its surface 12 times more, without leaving any space uncovered, that may be seen, even with a deep magnifier; thus, 16 ounces of gold, which, if in the form of a cube, would not measure *one inch* and *one quarter* on its side, will compleatly gild a quantity of silver wire sufficient to circumscribe the whole globe of the earth. *The Editor*, from *Wallerius*, *Reaumur*, *Nicholson*, *Pauction*, &c.

[b] Gold is more elastic than *lead* or *tin*; but it has less elasticity than *iron* or *copper*. *Fabr.*

However, when hammered, it becomes harder. *Bomare.*

It has not only a *ductility* greater than any other metal, but the *tenacity* or *cohesion* of its particles exceeds that of others. A wire of gold, not thicker than the *tenth* of an inch of the *Rhine foot*, can hold 500 pounds weight, without breaking. *Wallerius* and *Bomare.*

in

in form of ſmoke, and partly to ſcorify; but this wants to be farther examined. (*See Sect.* 264.) It is alſo ſaid that gold, in certain circumſtances, and by means of certain artifices in electrical experiments, may be forced into glaſs; and that on this occaſion it becomes *white*, leaving a *black duſt* behind it [*c*], which, if ſo, confirms certain other chemical experiments; viz. that gold can, together with its colour, loſe ſomething of its phlogiſton, and yet retain its heavineſs, ductility, &c.

6. When melted, it reflects a bluiſh-green colour from its ſurface [*d*].

7. It

[*c*] This muſt be a miſtake of the Engliſh Editor, unleſs the author has been himſelf groſſly miſinformed. It is true, that fine gold is intimately (though not uniformly) united to, or forced into, a glaſs ſurface, by the electrical exploſion; even ſome part of it becomes calcined, producing fine purple ſpots on the glaſs, as I have ſeen ſometimes: and Dr. Prieſtley aſſerts the ſame, in his *Hiſtory of Electricity*; but the metal never turns *white*, nor does it leave behind any *black duſt*, if it is pure. *The Editor.*

[*d*] When gold is expoſed to fire, it becomes red-hot long before it melts: in this caſe it has a brilliant greeniſh colour, inclining to blue; and, when cold, cryſtalliſes into quadrilateral pyramids. *Mongez.*

I have ſaid, in the *note* to *page* 510, that gold-leaf exhibits a fine green colour, by tranſmitted light, a fact which every one may eaſily verify; and the ſame phenomenon takes place, when the metal is ignited, as juſt now obſerved. The green light is tranſmitted in both caſes, ſince all reflected colours are produced by the tranſmiſſion of light, as the ingenious Philoſopher Mr. Delaval has lately diſcovered and demonſtrated,

 in

7. It dissolves in *aqua regia*, which is composed of the acids of sea-salt and nitre; but not in either alone, nor in any other solution of salt or acid whatsoever. [e].

8. When

in his very elaborate Treatise upon this subject, *inserted in the second vol. of the* Memoirs, *published in* 1785, *by the* Philosophical Society of Manchester. Sir Isaac Newton, in his Opticks (page 162, edition of 1730), accounts for that phenomenon, saying, that *gold foliated, and held between the eyes and the light, looks of a greenish blue*; *and therefore*, says he, *massy gold lets into its body the blue rays, to be reflected to and fro within it, till they be stopped and stifled, whilst it reflects the yellow outwards, and thereby looks yellow.* It is therefore in the two above cases, that some of the *blue* rays are transmitted along with the *yellow* ones, and both together appear of a *green bluish colour*, since every one knows, that blue and yellow together make a green colour. If gold be exposed to the joined rays of light, except only the *yellow* ones (which we suppose stopped after they were separated by a prism), it only looks *white* like *silver*, *which shews*, says Sir Isaac Newton (p. 166.), *that its* yellowness *arises from the excess of the* intercepted rays *tinging that* whiteness *with their colour, when they are let to pass.*

It is a pleasing observation to look with a deep magnifier on various pieces of *gold*, *silver*, and *Dutch* (copper) *leaf*, between the eye and the sun-shine. The particles of *Silver* are seen in the form of oblong dark lumps, with some interstices, like net-work, between them: those of the *copper leaf* are more numerous and more regularly distributed; but the particles of the *gold leaf* appear like little green semi-transparent and similar particles, joining between themselves by nearly diaphanous joints, as if they were forced to flatten in their edges, rather than they would break their mutual union between one another. *The Editor.*

[e] Gold is not only dissolved in *aqua regia*, but also in the *dephlogisticated marine acid.* As to the pure concentrated

8. When mixed with a volatile alcali and a little of the acid of nitre, by means of precipitation out of *aqua regia*, it burns off quickly, in the least degree of heat, with a strong fulmination. (*See Sect.* 264.)

9. It is dissolved, *in formâ siccâ*, by the liver of sulphur, and also somewhat by the glass of bismuth [*f*].

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nitrous acid, it rather tears, or corrodes the particles of gold, than makes with it any real solution, since it is enough to shake it, to free the metallic particles from the acid, and cause them to fall to the bottom, as *Wallerius* and *Mongez* assert. *See Note* [*y*] *to page* 289. The Editor.

By distilling vitriolic acid from off manganese, an acid is obtained, which alone is capable of dissolving *gold*, *silver*, and *mercury*, very readily, as Dr. Crell affirms in a letter to Mr. Darcet. Journ. de Physique, Oct. 1785, p. 297.

The solution of gold in *aqua regia* is accompanied with effervescence; is of a yellow colour more or less deep; tinges animal substances of a deep purple colour, and corrodes them. Its causticity is considerable: after a proper evaporation, it gives yellow crystals; if these are distilled, produce a fine red liquor, to which the Alchymists gave the name of *Red Lion*. Fourcroy.

[*f*] Neither *sulphur*, nor *fixed alkali*, have any action on gold; but the *liver of sulphur*, which is a compound of both, can dissolve it in the *dry-way*; so that if a proper quantity of gold leaves is put in a crucible, together with *liver of sulphur*, and it is melted in a brisk fire, the gold is thoroughly dissolved; and if the whole is diluted in water, the gold will be kept in the solution, and even pass through the filtre along with it.

Gold, as well as silver, is so much attenuated by bismuth, that it may be advantageously employed in their coppellation, as Keir asserts in his notes to *Macquer's Dictionary*; but Poerner, quoted also by the same Author, in his second edition, is of a contrary opinion. *The Editor.*

10. It is not carried away by the antimony during the volatilisation of that semi-metal, and is therefore conveniently separated from other metals by the help of crude antimony, in which process the other metals are partly made volatile, and fly off with the antimony, and partly unite with the sulphur, to which the gold has no attraction, unless by means of some uniting body, or by a long digestion [g].

11. The phosphorus is said to have ingress into gold [h].

12. If mixed with a small proportion of silver, platina, copper, iron, and zinc, it preserves its ductility tolerably well; but,

13. When mixed with tin it becomes very brittle; and it attracts likewise the smoke of

[g] Antimony is used also to refine gold from its alloy, as it attenuates and carries off all other metallic substances mixed with it, without excepting the silver; whilst lead leaves this last behind, and even adds some of its own to the gold. *Pauction, p.* 659.

[h] Gold, reduced into thin leaves, is not acted upon by the phosphoric acid in the *humid way*, though the fire be urged till luminous decrepitations take place; but when it passes that point, which separates the *humid* from the *dry way*, Mr. Margraff observed, that some purple scoria were formed, which is an indication that this concrete acid had partly calcined the gold during its fusion. *Elements de Chymie de Dijon, Vol. III. p.* 131.

Besides this, a drop of the phosphoric acid on the solution of gold by *aqua regia*, precipitates the metal in its revived state, as asserted by the same Academicians of Dijon. See Note [b] to p. 314. *The Editor.*

that metal, so as to be spoiled, if melted in an hearth where tin has been lately melted [*i*]. And this is perhaps the reason why gold becomes brittle, and of a paler colour, when melted in a new black lead crucible [*k*].

14. It requires a strong heat before it melts, nearly as much, or a little more than copper.

15. It mixes or amalgamates readily with quicksilver [*l*].

16. It is not dissolved by the glass of lead, and therefore remains on the cuppel.

In consequence of these its principal qualities, it seems as if gold could never be found in the earth, but in a native or pure state; there are, however, several instances where it has been found dissolved or mineralised [*m*]

[*i*] The fumes only of a single grain of tin are capable of rendering hard eight ounces of gold; but it easily recovers its malleability by being melted on the fire. *Wallerius* and *Bomare's* Mineralogy.

But when gold is mixed with *arsenic*, *cobalt*, *nickle*, *bismuth*, or with the *regulus* of *antimony*, it only loses great part of its malleability; and when in a certain proportion, it may be calcined and vitrified with them. *Fabroni.*

[*k*] The Author supposed (in the first edition) that *black-lead* contained *tin*; but late experiments shew, that it does not contain any. *See Sect.* 231. If the fact, asserted by the Author, is constant, it must proceed from some other cause.

The Editor.

[*l*] There is a very peculiar and strong attraction between gold and mercury; and it seems to be greater than that between the *load-stone* and *iron*. Wallerius.

[*m*] Those instances, mentioned by the Noble Author, as proofs of gold being found *mineralised*, are disputed by some eminent Mineralogists, though upon doubtful grounds, as will appear by the Sect. 263. *The Editor.*

SECT. 262. (165.)

A. Native Gold, *Aurum nativum.*

Is in its metallic form *commonly* pure; and in this ſtate moſt part of this metal uſed in the world is found [a]. With reſpect to either,

[a] This muſt be a miſtake of the editor of this work, as it is well known that native gold is generally found impure. Bergman openly acknowledges not to know that it has ever been found perfectly pure: and Kirwan only allows that it is ſeldom found ſo, being generally alloyed with *ſilver*, *copper*, or *iron*, or all three. As to the gold, commonly uſed in jewels and other objects of luxury, every one knows that it is purpoſely debaſed, by the artiſts, with copper or other metals; and of late it has been employed in various pieces of jewellery, forming ornaments of various colours; as a great alloy of *ſilver* (viz. one-third part) gives it a ſhade of a green colour; a ſimilar quantity of copper, a *reddiſh* one; a mixture of arſenic, or filings of ſteel, in the proportion of one-fourth part, gives it a *blueiſh* caſt; ſo that having the *yellow* naturally in the pure gold, and the *white* in pure ſilver, the jewellers have almoſt all the colours to diverſify their work.

Even in the currency of money, there is none coined out of pure gold, which, by common agreement, is called *gold of 24 carats.* The gold coin of England, France, and Portugal, only contains 22 parts of *pure gold*, and 2 of alloy; *viz.* it is only of 22 *carats*, in the common ſaying; that of Spain is but of $21\frac{19}{32}$ carats; but the *ducat* of Holland is of $23\frac{24}{32}$ carats; and the *zecchino* of Venice, of $23\frac{28}{32}$ carats: this laſt is the pureſt gold coin, as it ſeems, of Europe at leaſt. *The Editor, chiefly from* Paucton's Metrologie.

the

the figure or the quantity in which it is found in one place, it is by miners divided into [b].

1. Thin superficial plated or leaved gold, which consists of very thin plates or leaves, like paper [c].
2. Solid or massive, is found in form of thick pieces [d].

3. Cryf-

[b] Wallerius distinguishes native gold by the following 6 forms; *viz.*

1. In *solid* masses; found in *Hungary*, *Peru*, and *Transylvania*.
2. In a *granular* form, found in the Spanish West-Indies.
3. In a *vegetable form*, like branches or twigs of plants.
4. In a *drusic* figure, as if composed of *groups*, or clusters of small particles united together; found in Hungary.
5. In a *superficial* form, composed of thin plates, or thin pellicles covering other bodies, found in Siberia.
6. And crystallised, found in *Hungary*.

Finally, Mr. Daubenton, in his *Methodical Tables of Minerals*, enumerates 8 sorts of native gold; *viz.* 1. in powder. 2. in grains. 3. in small spangles. 4. in masses or lumps. 5. in filaments. 6. in branches like vegetables. 7. in lamells; and 8. in octoedral crystals.

The same Natural Historian says also, that gold, in its reguline state, is either 1. formed into angular crystals, composed of yellow octoedres; or 2. into irregular yellow masses, which, being broken, shew a granular substance. *The Editor.*

[c] Native gold in a form of leaves, is always crystalized on its surface.

These crystals are very small: with a microscope, one may discover their triangular pyramidal form.

In Transylvania, I have procured a specimen of cubic native gold, but never saw it any where else.

The crystals on the stone, are of the size of small hemp-seeds. *Brun.*

[d] Gold is in general more frequently imbedded and mixed with quartz, than with any other kind of stone; and the quartz in which the gold is found in the Hungarian gold mines

3. Cryftallifed, confifts of an angular or criftalline figure [e].

4. Wafh gold, or gold-duft, is wafhed out of fands, wherein it lies in form of loofe grains and lumps [f].

SECT.

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mines, is of a peculiar mild appearance. All other forts of ftones, however, are not to be excluded, fince gold is likewife found in fome of them; for inftance, in lime-ftone (Sect. 9.) in Adolph Fredrik's Grufva, at Adelfors, in the province of Smoland; in Hornblende (Sect. 137.), in Baftnas Grufva at Riddarfhyttan, in the province of Weftmanland; not to mention feveral foreign gold mines.

The greateft quantity of gold is imported into Europe from Chili and Peru, in America; and a little from China, and the coaft of Africa. The chief European gold-mines are thofe of Hungary, and next to them that of Saltzburg. Befides thefe, there are fome others of lefs confequence; among which the gold-mines at Adelfors in Smoland deferve to be taken much notice of, not only on account of the veins already worked, but alfo in regard to the vaft tract of land, within which new veins are daily difcovered. The filver, from the mines of Ofterfilvarberget in the province of Dalarne, contains from 4 to 7 grains of gold in the mark. Some native gold has likewife been found in Swappawari, above Tornea in Lapland, and in Baftnas, near Riddarfhyttan, in Weftmanland. *The Author.*

[e] The cryftalline form of gold is the *octoedral rectangular one*, for the moft part; but it is alfo found in the form of fmall drufical cryftals: fometimes branched like *dendrites*, and fometimes folitary. There are alfo cubic cryftals of this metal (Note *z*), all which evidently fhow how little can we truft to the teft of cryftalline forms, in order to diftinguifh mineral fubftances from one another. *The Editor from* Wallerius, Romé de l'Ifle, &c.

[f] Wallerius diftinguifhes this kind of gold-ore by the various earths and fubftances with which it is mixed; and by the different colours it affumes from them as the *ochreous*, *margaceous*,

margaceous, and *argillaceous* gold ores; those mixed with *red granatic sand*, or with *black* and *lead-coloured sand*, &c.

Native gold is found also *separate*, from any matrix in lumps, or visible grains mixed with sand; and in this state it is found in many rivers of *Europe*, *Africa*, and elsewhere, or visibly dispersed through large masses of sand, particularly the yellowish red, or violet; and, in this state, it is so generally diffused through all species of earth, though in exceeding small quantities, that Mr. *Bergman* thinks it more universally found than any other metal, except iron. If 100 pounds of sand contain 24 grains of gold, it is said the separation is worth attending to; but in *Africa* 5 pounds of sand often contain 63 grains of gold, or even more; the heaviest sand, which is often black or red, yields most. In *Hungary*, 10,000 pounds of sand yield but 10 or 12 grains of gold; it was extracted, but with loss. *Born's Letters from Hungary*, quoted by *Kirwan*.

Most great rivers carry gold with them; even such as do not take their rise in those mountains where gold is found; it is therefore no wonder, that all rich gold-mines enrich their rivers with this metal.

The river *Avanyos*, in Transylvania, affords subsistence to upwards of 700 gipsy families, who collect the gold from it.

In Brasil the gold is found in so great abundance, that their torrents are often driven, with very considerable labour and expence, to new beds, in order to gather the gold there deposed by the running waters. But it is also found there mingled within the earth in various shapes and forms.

In Peru gold is found with a stony matter, not well known, and a red earth, from which it is there extracted by amalgamation with mercury. *The Editor, chiefly from* Kirwan.

The celebrated Naturalist, Mr. Pallas, speaks in the Account of his Tour through Siberia, of three gold mines that are worked there, near the river Pyschma, in which 500 men are employed. The gold is found in a powdery form, and also in thin small plates, or leaves. Sometimes kernels, or lumps of a spongy texture, and very light, are met with, in which a good quantity of gold-dust is loosely contained. The ore it found in a white clay, though, for the most part, it is of a grey yellowish colour, intermixed with mica. An argill, of a fine red colour, is also found in these mines. It was near

them

SECT. 263. (166.)

B. Mineralized Gold, *Aurum mineralisatum*.

This is an ore, in which the gold is so far mineralised, or enveloped by other bodies, as not to be acted on by the aqua regia.

1. Mineralised with sulphur, *Aurum sulphure mineralisatum* [a].

2. Mineralised

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them that the red lead-ore, described by Leheman, was discovered. But these Siberian mines do not seem to produce above 400 marks of gold in the year, and could not pay the expences of being worked in a less cheap country than Siberia. *See Journal de Physique for* June 1783. *The Editor.*

Wolkemann, quoted by le Camus, asserts, in his *Soterraneous Silesia*, that gold is also found, sometimes in veins, running through beds of coals. *Journ. de Physique, for March* 1779, *page* 183.

And Mr. Eller of Berlin, had, in his Collection, an ore, which contained *gold*, *silver*, *iron*, and *quicksilver*, closely united together in the same mass. Watson's Chemical Essays, Vol. IV. p. 157.

[a] Since gold and sulphur have no attraction to one another, many have insisted, that gold never can be found in marcasite, or those ores which contain sulphur: but since we know by experience, that gold can be melted out of the above-mentioned Ores, although they have been previously digested in *aqua regia*; and that gold likewise enters into their sulphurated regulus; there is the greatest reason to believe that a third substance, which here is a metal, must necessarily have, by its admixture, enabled the sulphur to unite with a certain quantity of gold. Scheffer has given upon this subject some very curious and useful observations, in his History of the Refining of Metals, inserted in the Transactions of the Academy of Sciences at Stockholm. It is very remarkable, that the Mine-

Master

2. Mineralised by means of iron. *Aurum sulphure mineralisatum mediante ferro.*

Marcasitical gold ore. *Pyrites aureus.*

It is found at Adelfors, in the province of Smoland; and contains one ounce of gold, or less, in an hundred pounds [*b*].

3. Mineralised

Master Henckel, author of that excellent Treatise *de Appropriatione*, should be so obstinate in denying that marcasite could contain a dissolved gold.

It is, however, by no means hereby intended to confirm the credulous in their opinion, that the marcasites in general contain more gold than what true metallurgists have asserted; because fraud might then perhaps become too common. It is only meant to indicate, that, as no gold is to be expected from marcasites, where no native gold is found in the neighbourhood; in the same manner no marcasites ought to be despised, which are found in tracks where gold ores are dug; but at the same time care must be taken not to be deluded by the mention of volatile gold, as it is a notion really contradictory and suspicious, and then there can be no fear of being misled.

I am not perfectly clear, whether the gold is really dissolved and indurated, or, if I may so express myself, vitrified in the Shirls (Schirlkornern), provided by this mineral body is meant a garnet substance (Sect. 68. of the Author). But I have seen a piece of what is called *Shirl*, whose texture was exactly like the Schemnitz blende; and, in this case, it might perhaps hold the same contents (Sect. 175. of the Author). For the other gold ores, I have not had an opportunity of seeing any from those places where gold is searched for and really found. *The Author.*

[*b*] This Pyrite is of a bright yellow colour, close and compact. The gold in this ore is said to be *mineralized* by sulphur, by means of iron, because it cannot be extracted by *aqua regia*, or by amalgamation. *Kirwan.*

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3. Mineralised by means of quicksilver, *Aurum sulphure mineralisatum mediante mercurio*, auriferous cinnabar. It is said to be found in Hungary [c].

4. Mineralised

It is well known, that gold may be dissolved by *liver of sulphur*; the following is the process given by Apligny (p. 156. of his *Treatise on Colours*).

Pound *four pounds* of vegetable alkali (salt of tartar), and as *many* of sulphur, with *one* of leaves of gold; melt the mixture in a crucible with its cover; pour the fused matter on a marble; pound it again when cold, and put the whole in a matrass, with hot water; which, being filtrated, is of a yellow greenish colour, containing the gold dissolved. Now, as we know that *hepar sulphuris* has been found in several pyrites, and Mascagni asserts (p. 279. of his *Commentario*) to have found it in those of the lagoons near Sienne, in Italy; is it not very natural to conclude, that this noble metal may be really mineralized in the auriferous pyrites? *The Editor.*

The Transylvanian gold pyrites, in which no gold can be discovered by the eye, hold from 50 and 100, to 110 ounces and upwards, in an hundred weight. Those, where the gold appears in the pyrites, like strewed Spanish snuff, hold 250 ounces, but they are very scarce. The mountain of *Faczebaya* near *Zalathna*, is remarkable for its gold pyrites; they seem likewise to contain semi-metallic parts. *Brunnich.*

[c] Mr. Sage, quoted by his two great admirers, Messieurs Romé del Isle (p. 420. Vol. I. of his *Crystallogie*), and Dr. Demeste (p. 466. of his *Letter* 44.), speaks of a specimen of gold from Hungary, now in the French King's cabinet at Paris, which is crystallized into quadrangular prisms, of a grey-yellowish colour, and of a brittle consistency. This Mr. Sage asserts to be the result of a mercurial amalgam of native gold. *The Editor.*

They sometimes find quicksilver in the chafts of the mines of *Michael* and *Siglisberg*, near *Shemnitz*; but the people have no idea of its containing gold, which may be the case, if it were well separated. It is most probable that the other Hungarian cinnabars contain none; but I shall be able to

7 speak

4. Mineralised by means of zinc and iron, or silver. *Aurum sulphure mineralisatum mediante zinco & ferro, aut argento.* The schemnitz blende [*d*].

At Schemnitz, in Hungary, are found zinc ores, which contain a great deal of silver, and this silver is very rich in gold. *See Sect. 175. of the Author.*

SECT.

speak of this with more certainty, after I have made trials with them. *Brunnich.*

[*d*] Wallerius speaks of two kinds of this ore; one, the *Pseudogalena aurifera rubens*, found in *Schwarzenberg* mine of Saxony; and the *Pseudogalena aurifera nigrescens*, which is reckoned amongst the *silver ores*, the gold being in a very small quantity, found at *Schemnitz*, in Hungary.

But Professor Brunnich, in his notes to this Section, enumerates the following varieties of mineralized gold ores; *viz.*

5. Mineralized by means of a cubic lead-ore containing silver. From the mines of Michaeli, and some shafts in Transylvania.

6. Mineralized by means of a copper pyrites, with silver. Is called *gilf* in Hungary; has a compact pale yellow surface, and must not be confounded with gold pyrites.

7. Mineralized by means of red gilder-ore. The *Cremnitz ores.*

8. Mineralized by means of antimony, in which it sometimes appears. From the mountains of *Magarca* or *Margara*, near *Deutschlipsh*, at the foot of the Carpathian mountains.

9. Mineralized by means of cubic lead-ore, iron, and unknown volatile parts. From Nagyai, near Deva, in Transylvania. Scopoli describes this ore in his third *Annus Historico Naturalis*, as follows; Its colour is black; the richest pieces are lamellated almost like an iron-glimmer, with a degree of flexibility. The vein is quartz, which is sometimes loose, and wherein the ore is very minutely scattered.

10. Native gold, with *black-lead* (or *molybdæna*), has been broken near *Rimezembat* in *Upper Hungary*; but whether it has been mineralized with it, I have had no opportunity of examining.

In

SECT. 264. (Additional.)

Obſervations on Gold, and its mineralizations.

Gold is juſtly called the *King of Metals*, as it is the moſt ductile, maleable, heavy, and unalterable of all metals. When expoſed to air, immerſed in water, or buried in the earth, ſuffers neither decompoſition in its ſubſtance, nor ruſt, or even change of colour in its ſurface, although the duſt, or appoſition of external particles, may diſguiſe its luſtre; but, on being

In all the above ſpecies, the gold is either intirely native; but ſo minutely divided, and ſo looſely ſcattered, that it can only be ſeen through microſcopes, and often cannot be ſeen at all, before it is ſeparated by various proceſſes; or it may not be in form of native gold, but as a gold as it were in embryo; in which caſe fire is neceſſary, in order to bring the conſtituents parts together, and to add thoſe that are wanting; in that caſe likewiſe it is never without ſilver. *Brunnich.*

To the above may be added the following ores;

11. Gold, with *arſenical pyrites*, is found alſo at *Saltzberg* in *Tyrol*, in mountains of quartz and ſhiſtus. It contains only 25 grains in the quintal; and, nevertheleſs, this mine affords a profit of 500 pounds *per annum.*

12. With a *white, red, or vitreous ſilver ore*, near Cremnitz, and Schemnitz, in Hungary.

13. With a *ſulphurated* ore of *ſilver, iron, lead*, and *mangeneſe*, at Nagaya in Tranſylvania. Its ſpecific gravity is = 4,043. It is ſaid to afford 10 ounces per quintal.

14. With *ſulphurated iron, copper*, and manganeſe, at Nagaya. *The Editor*, from Kirwan, Mongez, Bomare, &c.

waſhed

washed off, it appears as bright as before; and when exposed to the most violent fire, is quite fixt, without suffering calcination, nor sensible change or loss in its mass.

Messieurs Boyle and Kunkel kept gold constantly fused in a violent heat, during two months, and found not a single grain to have been lost. It is true, that when exposed to the focus of a large burning lens, it is evaporated, but without changing its metalic state. The late celebrated Professor Macquer shewed me, at Paris, a plate of pure silver, which he had exposed to that visible atmosphere, which surrounded the said melted gold; and, by means of a magnifier, numberless particles of the gold could be very well discerned as attached to its surface. This accounts for the assertion of Mr. Lavoisiere, in the *Memoires* of the *Academy of Sciences* at *Paris*, for 1782, who says, that gold, when exposed to the flame of a lamp, blown by a current of dephlogisticated air, (which is the most violent degree of heat that has ever been produced, and is one of the most important modern discoveries) is intirely volatilized, without leaving behind the least mark of calcination.

However, Mr. Kirwan observes, that on exposing gold to the focus of that most powerful lens, made by Mr. Parker, in London, for some hours continuance; although it lost no sensible part of its weight, yet, when in contact with earthy matters, it communicated a blue or purple tinge to them; from whence it appears that some minute, though insensible portion of it, was really dephlogisticated.

If a solution of gold in *aqua regia* be properly mixed with that of tin dissolved in the same menstruum, a fine *purple powder* is precipitated, called by the name of *Cassius*, its inventor, which produces the finest lasting purple colour. This powder, mixed with vitreous substances, is employed preferably to any other, by encaustic painters and glass-manufacturers. The late famous Chymist, Mr. Macquer, describes, with great accuracy, in his Dictionary, various processes to obtain, with certainty, this precious calx of gold.

If volatile alkali is added to the same solution of gold by *aqua regia*, a reddish yellow powder is precipitated, which is the *aurum fulminans*. It is also commonly made, by dissolving gold in a kind of *aqua regia*, made with *nitrous acid* and *sal ammoniac*, from which the *fulminating gold* is afterwards precipitated by the fixed alkali. A few grains of this powder detonate with a prodigious noise. When exposed in a metallic spoon or plate, over a candle, coals, or a red hot iron; or when, by other means, it is sufficiently heated, its fragor is 64 times greater than an equal quantity of gun-powder.

A degree of heat, as between the 120 and 300° (at which the nitrous and vitriolic acid boil) is sufficient to produce this amazing explosion, by which the most violent effects are produced. *Ten* or *twelve grains*, exploded on a metal-plate, perforate and lacerate it; and a few ounces, having

having exploded together, by incautiously drying it, have shattered the doors and windows of the apartment.

Even simple triture, or percussion alone, is enough to cause this powder to explode with all its violence, by which dreadful accidents have sometimes happened. Macquer relates the case of a young man of his acquaintance, 22 years old, who shutting up a small bottle of crystal, with about a dram of this powder, some little of it, between the stopple, was kindled by twining it: the bottle burst into pieces, by which he was violently struck; fell to the ground, and his eyes were quite shattered, so that he remained irrecoverably blind. And it is remarkable, that the greatest part of the contents in the bottle did not detonate, a quantity of them being found unaltered and dispersed in the room. Professor Bergman has published a very elaborate dissertation on this *fulminating powder*, in the second vol. of his Opuscula; but this wonderful phenomenon seems not yet compleatly accounted for in any hypothesis as yet known, nor even in that proposed by the celebrated Scheele, in his *Treatise on Fire*, Sect. 82. as he supposes there what seems not at all admissible; *viz.* that the *matter* of *heat* is a compound of *phlogiston* and *dephlogisticated air*. See Note [*f*] to page 347. of this *Mineralogy*.

It is on account of the singular and excellent natural qualities of this metal, which are considerably heightened by its scarcity, that gold is so much valued among all the civilized nations of the world, as the Noble Author said in Sect. 261. Mr. Paucton, in his *Metrologie*, p. 94. says, that one cubic foot (French measure) of gold, is worth 2153000 *livres tournoises*, or 89708 *guineas* and 7 *shillings*, supposing the *louis d'or* equal to the *guinea*; and that the respective value of the same *cubic foot* of gold, is equal to 25,6 cubic feet of silver, each of this last metal being reckoned worth about 84080 *French livres*, or 3503 *guineas* and 8 *shillings*; so that if we suppose the monied species in *France* to be but two *milliards* of *French livres*, according to the estimation of Mr. Necker, in his treatise upon the *Commerce of Corn*, the whole amount should make but a solid cube of gold, less than *ten feet* on each side. So trifling is the physical object that excites the activity of 22 millions of the human species, the number that is said to be that of the inhabitants of France!

As to the natural existence of gold in the bowels of the earth, there have been two opposite opinions among Mineralogists; some pretending, that it is only found in its *metallic* or *native form*; and others, that it is sometimes found *mineralized*, in an intimate union with other mineral substances. The famous Professor Bergman was among those of this last opinion; but Mr. Kirwan holds the first, and says, that although Mr. Bergman inclines to the opinion of the mineralization, yet he is candid enough to own, that the gold, when extracted from this

ore,

ore, is of a granular, or angular form. It is therefore, says Mr. Kirwan, very doubtful whether it was not rather *mixed*, than truly *combined*, with the sulphur and iron: and its proportion being exceedingly small, so that one hundred pounds of the pyrites contain hardly one ounce of gold; it is not a wonder, that it should escape the action of *aquâ regia*; more especially, as the nitrous acid becomes so phlogisticated, by acting on the pyrites, as not to be able to dephlogisticate the marine. Likewise Mercury, by the circumstantial accident of the gold particles being enveloped, or surrounded by the sulphureous iron, can have no access to it.

These arguments against true mineralization of gold, are fully answered by those facts, and reasonings, expressed by the Noble Author in the preceeding Sect. 263, and in its notes. Besides, it is well known, that gold can be combined and calcined *via sica*, by the *liver of sulphur*, and some semi-metals, as has been said in the same Notes. This being acknowledged on both sides of the question, why should we insist in denying this mineralization, when it is out of doubt, among all Mineralogists of rank, that volcanic fires have had a great share in the convulsions and revolutions of this globe, of which every one has the most convincing proofs almost every where? The account given by Mr. Hacquet [a], of

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[a] By this account of Mr. Hacquet, it appears that gold is found mineralized; *viz.*

1. By *sulphur*, zinc, and arsenic, in a grey-yellowish volca-

of the gold mines at Nagy-Ag, in Tranſylvania, the ancient Dacia, which lies about 45 *degrees* of latitude, offers the moſt convincing proofs of this aſſertion. The country all round theſe mines, bears an inconteſtable appearance of being a volcanic one; and among various other metals, there are found at leaſt 13 kinds of gold-ores, moſt of them mineralized. *The Editor.*

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nic ore, which is called *Cottoners* (or Cotton-ore), on account of its lightneſs and texture.

2. By iron and arſenic, formed by ſtrata, one containing black ſilver ore, then ſpatum, galena, quartz, and grey gold ore: it gives about half an ounce *per cent.*

3. By ſulphur, antimony, zinc, ſome arſenic, and ſometimes iron; this is a grey gold-ore mixed with quartz.

4. In form of crooked threads, mixed with quartz and gypſeous ſpath: it is a poor mine.

5. Dendritiforme, like the mocho-ſtone, or the agate from Aberſtein, in the Palatinate, but theſe black dendrites are in a reddiſh ſtone,

6. A morphous very compact in ſmall grains, with ſpath and quartz: it gives two ounces of gold, and more of ſilver, *per* quintal.

7. By ſulphur, great part of zinc, and little of antimony and arſenic: not a rich ore of gold.

8. Of a black, or dark reddiſh colour, containing an auriferous pyrites, not rich.

9. Of a blueiſh colour, mineraliſed by ſulphur, antimony, iron, and a little arſenic, mixed with ſilver; very rich in gold.

10. Partly laminated with needles of a blackiſh yellow colour; this gives 66 oz. *per* ℔ of gold according to Scopoli.

11. Foliated with gypſeous ſpath, and yellow pyrites.

12. In irregular lamina, on a greyiſh argille. The gold looks like ſilver, and is ſurrounded by ſpars of a pale roſy colour.

13. In

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2. Silver, *Argentum*, *Luna*. This Metal is

1. Of a white shining colour [a].

13. In cryſtallized lamina, from 2 to 4 lines diameter, of an hexangular form; it is very much like the *molybdene*. Profeſſor Brunnich, on this account, calls this ore, but improperly, *minera auri martialis pictoria*. The vein has been loſt a long while; but a new branch was lately met with, on mining for letting out the water from the main. This ore is very rare, and has given 372 ounces, *per* ℔ of noble metal, 5 parts of which were gold, and one ſilver. *The Editor from Journal* du Phyſique, *for January* 1785.

[a] Silver, called *Luna* or *Diana*, by the alchemiſts, is a perfect metal, the whiteſt and of the moſt vivid brilliancy among them all.

Its ſurface, however, *tarniſhes*, and becomes of a *dark brown* colour, when expoſed to *hepatic*, or phlogiſtic efluvia (N° 10.). If rubbed on a paper, or on a chalky white ſurface, it leaves *blueiſh* marks. Its calx being precipitated by volatile alkali, gives a *yellow* tinge to glaſs (*See* Gellert's *Metal. Chym.* p. 301.): and I have ſeen ſome ſtained with it of ſo high a colour, as to appear quite *red*. Mr. Macquer, by expoſing the ſame ſilver, 20 times, to a very violent fire, found ſome little vitreous calcinations of an *olive* colour. And by melting ſilver with *gold*, or *ſteel*, in a due proportion, it aſſumes a *greeniſh*, or a *blueiſh* colour; ſo that this noble metal is capable of producing the *white*, *yellow*, *red*, *green*, *blue*, and *olive* colour, more or leſs conſpicuouſly, according to the various circumſtances of heat, and proportions of the mixture.

Fourcroy ſays, that ſilver has neither *ſmell* nor *taſte*, when pure. But its diluted ſolution has a particular diſagreeable taſte, very different from that of other metals.

Silver is ſo fixt by itſelf in the fire, that, after being kept a whole month in fuſion, it had only loſt one 60th part of its weight, which might be on account of ſome alloy. It is therefore incapable of being calcined by mere heat; and the calx of ſilver, which can only be made by means of its ſolu-

2. Its specific gravity to water is as 11,091 1000 [b].

3. It is very tough or ductile, so that a grain of it may be stretched out to three Swedish ells, of 2 feet each, (or 5 *feet* 8 *inches* English measure), and two inches in breadth.

4. It is unalterable in air, water, and fire.

5. It dissolves in the acid of nitre, and also by boiling in the acid of vitriol [c].

6. If

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tion in acids, is reducible to its metallic form, without the addition of any phlogistic substance.

But when silver is exposed to the violent heat of the solar rays, collected by a powerful burning lens, a kind of smoke is seen surrounding it, which proves at last to be the minute particles of the metal raised and dispersed by heat; as is evident, if a thin plate of gold is exposed to it, on which surface they may be seen with a magnifier. This is the same phenomenon which was observed on gold, when in similar circumstances. *See page* 529.

If it is slowly cooled, after having been fused, it crystallizes into octoedral figures, though seldom perfectly so; for the most part it only shews the half of them, appearing like so many quadrilateral pyramids. *Editor chiefly from* Wallerius, Fourcroy, Bomare, Mongez, &c.

[b] Its specific gravity, according to Bergman, is = 10,552; but, according to Kirwan, it is = 11,095. *See the Note* [b], to Sect. 295. *On the causes of variation of the specific gravities of bodies.*

A cubic French foot of Silver weighs 720 pounds of *French weight*, according to Macquer. As to its relative value, see p. 532.

Silver is harder and more elastic than *lead*, *tin*, or *gold*; but is softer than *iron*, *platina*, or *copper*. It stiffens under the hammer, but becomes soft by nealing: and is the most sonorous of all pure metals, except copper.

A silver wire, a tenth of an inch thick, may support, without breaking, 270 pounds weight, according to Macquer, Fourcroy, and Bomare; but Wallerius carries it farther, unless there be some typographical error, saying, it may hold

370 pounds,

6. If precipitated out of the acid of nitre with the common salt, or with its acid, it unites so strongly with this last acid, that it does not part from it, even in the fire

370 pounds; and asserts, that a vessel may be made so thin of this metal, without being heavier than a single *grain*, which will hold a cubic inch of water.

[c] Silver requires nearly twice its weight of nitrous acid to be dissolved; this is it's most specific menstruum; even cold, it attacks silver with a considerable effervescence, grows hot, and emits a large quantity of vapours of an orange colour, which diminish in proportion as the saturation advances.

The metal looks of a pale brown colour in the conflict; and the solution becomes quite black; but I have observed, that this last appearance was owing to a thin black fuliginous substance, like smut, which was at once formed into a crust on the surface of the thin plates of silver, in the first attack of the acid upon them. This black substance is a very singular phenomenon, which I know not how to account for. These black crusts being comminuted into smaller and smaller particles, by the intestine motion of the effervescing acid, produced the black appearance of the whole; and, when it was over, they were very distinctly seen to fall to the botom of the vessel, and to form a black sediment, leaving the liquid solution quite transparent, but of a blue colour inclining to green, which last might be attributed to some small mixture of copper, altho' the silver was of the pure kind, myself having bought it as such, from one of our best refiners, at *Foster lane* in *London*.

The Chemists of Dijon only say, that the nitrous solution of silver looks of a fine blue colour, if the acid is pure and well concentrated; but if it has any mixture of vitriolic or marine, a precipitate of *vitriolated silver*, or of *luna cornea*, takes place. Afterwards the solution becomes as colourless as water; but gives a lasting black-purple tinge to animal substances.

This solution is of great use in chemistry; and, in particular it serves to purify the *nitrous acid*, or *aqua-fortis*, from fire itself, but melts with it into a mass like glass, which is called *luna cornea* [*d*].

7. It

from the mixture of the *vitriolic* and *marine acid*, which are often mixed therewith; as, by pouring in it little by little a few drops of it, these two acids are precipitated, and the nitrous afterwards is decanted in a pure state. The same solution, diluted in distilled water, is a very nice test to discover any vitriolic, or marine part, contained in Mineral Waters.

The nitrous solution of silver, when properly evaporated, produces a large quantity of white crystals, of a scaly form; some are hexagonal, and some of an octoedral figure, which are called *Lunar Crystals*. This salt is fusible in a moderate fire; loses its water of crystallization; becomes black, and is very corrosive; on account of which quality it is cast into small cylindrical moulds, and is known under the name of *Lapis Infernalis*, as its use is to corrode the spongious flesh of sores, &c. According to Mr. Scheele, the dark colour of this caustic substance proceeds from the alloy of copper, for even the refined silver, by the common method, contains some of this metal. *See at the end of the following note* [*d*], *the best method of purifying* silver.

The nitrous solution of silver may be decomposed by *earthy*, *saline*, and *metallic substances*; and, when the decomposition is made by *mercury*, a very curious precipitate takes place, which, by its similarity to vegetables, is called *Arbor Dianæ*.

Aqua regia dissolves very well this metal, but it is immediately precipitated, forming a *luna cornea* with the muriatic part of this solvent. *The Editor, chiefly from the* Elements of Chemistry of Dijon, and Fourcroy.

[*d*] The marine acid attracts the calx of silver, but cannot remove its phlogiston; and therefore cannot dissolve it in its metallic state. *Bergman.*

However the marine acid, if well concentrated, or rather reduced into an aerial form, dissolves silver in its metallic state. *Fabroni.*

Mr. Scheele, and after him Mr. Bertholet, assert positively, that the marine acid, being dephlogisticated by its distillation over maganese, in the form of a yellow air or gas, dissolves

7. It does not unite with the semi-metal *nickel*, during the fusion.

8. It amalgamates easily with quicksilver.

9. It is, in the *dry way*, dissolved by the *liver of sulphur*.

10. It has a strong attraction to sulphur, so as readily to take a reddish-yellow or black colour, when it is exposed to sulphureous vapours.

11. It has no attraction to arsenic; whence when the red arsenical silver ore, or *Rothgulden Ertz* of the Germans, is put into the fire, the arsenic flies off, and leaves the sulphur (which in this compound was

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dissolves all the metals, without excepting *gold*, *silver*, nor *mercury*. See *Scheele's Essay* 5, §. 25 *H.*

The vitriolic acid, being distilled also over the manganese, dissolves *silver*, *gold*, and *mercury*, as Dr. Crell asserts. *See Note* [*e*] *to page* 517.

Silver is precipitated from the *vitriolic* and *nitrous acids* by the *marine*; and from the *nitrous*, in great measure, by the vitriolic. *Kirwan.*

The silver extracted from *luna cornea*, is purer than can be made by cupelation, and is the only one to be trusted to in the nicest operations of chemistry. But the process, to free it from the *muriatic acid*, is very tedious, and presents a very unexpected phenomenon, as this metal, though one of the most fixed kind, is nevertheless so volatilised thereby, that it escapes through the pores of the crucible; and small globules of silver are found afterwards in the cover, and even in the support of the crucible. According to Cramer, this loss may be prevented by smearing the crucible with *black soap*, and mixing to the *luna cornea* half its weight of oil or tallow, which last must also be added, little by little, during the operation. *See* Elem. de Chimie, de Dijon, Vol. II. p. 221.

the

the *medium uniens)* behind, united with the Silver in form of the glaſs-ſilver-ore, or *glaſs ertz.*

12. It is not diſſolved by the glaſs of lead, and conſequently it remains on the cuppel.

13. It is exhaled, or carried off by *volatile metals* and *acids*, as by the vapours of *antimony*, *zink*, and the *acid of common ſalt.*

14. It melts more eaſily than copper [*e*].

SECT. 266. (168.)

Native Silver.

Silver is found,

A. Native or pure, *Argentum purum nativum.*

Native ſilver moſt generally is nearly of ſixteen carats ſtandard [*a*]. It is found

[*e*] This was a general opinion, *viz.* that ſilver required a leſs degree of heat than copper to be melted in the fire, as the noble author aſſerts; but the contrary appears, by the nice thermometer lately invented by Mr. Wedgewood, as may be ſeen by the note to page 230. This new inſtrument is one of the moſt valuable acquiſitions of modern date, for all kinds of proceſſes, and philoſophical diſquiſitions in metallurgical, chemical, and various other operations of art by fire; all which were till now regulated only by gueſs, without any fixed ſtandard to aſcertain the real degree of heat belonging to each. *The Editor.*

[*a*] In the firſt edition of this Mineralogy, corrected by the late Dr. Lewis, uſe is made of the word *loths* inſtead of *carats*; and it is added, that native ſilver never is fully of 16 *loths*; which laſt is called the *Fine Mine* of *Silver.* By this it ſeems to be meant, that *native ſilver* is found nearly free, but never fully ſo, from *all baſe metals, as copper, lead,* &c. *The Editor.*

1. Thin

1. Thin superficial, plated or leaved.
2. It is also found in form,
 a. of snaggs, and coarse fibres.
 b. Of fine fibres. Capillary silver.
 c. Arborescent. From Potosi in America, and Kongsberg in Norway [b].
 d. Cristaline or figured. This is very scarce to be met with: it has distinct figures, with shining surfaces; it is, however, sometimes found at Kongsberg [c].

The silver from America is said to be found for the most part native; so it is likewise at Kongsberg in Norway [d].

It

[b] Sometimes silver is found, the surface of which resembles coarse linen, or what is called *knit cobalt* in Saxony; it is so found abundantly in Potosi, rarely at Saxony, and at Kongsberg; perhaps our author has reckoned these figures among the *dendritical forms*. Brun.

[c] There appears likewise a kind of crystallization on the thin plates of *native silver*, their surface being full of minute pyramidal crystals, in the same manner as the thin plates of gold which have been mentioned before. *Brun.*

[d] A good deal of it likewise breaks in Saxony among other rich ores. *Brunnich.*

Wallerius distinguishes the *native silver* into the following species; *viz.*

1. In *irregular masses* and *lumps*, found at *Kunsberg* in *Norway*, and at *Neumarken* in *Wermeland*, where it was in a bed of clay.
2. *Granular*, and in a jagged form, at *Potosi* and *Mexico*, in Spanish America; and at *Kunsberg*.
3. *Dendritiform* and *arborescent*, in the same places, and at *Schneeberg*.
4. *In thin leaves* between the fissures of stones, as at *Kunsberg*, *Freiberg*, *Johangeorgenstadt*.

5. In

It is not commonly so in other European mines. In Sweden it is found native in a very small quantity, in the mines of Salberg in Westmanland, of Lofasen in Dalarne, of Hevaswik and Sladkierr in the province of Dal, of Sunnerskog, in the Province of Smoland, and in the island Utoen in the Lake Malaren.

It was once found in pretty large lumps in a vein of clay, in one of the iron mines at Normark, in the province of Wermeland. It was there mixed with nickel, which was partly decayed or withered; and under this circumstance it formed the compound ore called the *Stercus Anserinum* or goose-dung ore (See sect. 282.) At this place the argillaceous vein crosses the veins of the iron ore, and will perhaps be found to have more of these riches, even in several other places, if well searched, as is done in other countries, oftentimes not on such evident marks or signs [e].

SECT.

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5. *In a capillary form*, at *Schemnitz*, in Hungary; at *Freiberg*, and at *Marienberg*, in Saxony. Of this kind is the *Cobweb silver* ore of the Spaniards.
6. In a crystallized form, at *Kunsberg*, and at *Sainte Maria* in Alsatia.
7. *Superficial*, at *Salberg*, and *Læfæsen*.

Mr. Daubenton reckons eight varieties of *native white silver*, arising from their peculiar forms: but he reckons separately some of the above forms. *The Editor.*

[e] The Mineralogical Academy at Freyberg, has some *native silver* in *coal*; this is shewn there among the Konsberg pieces. *Brunnich.*

And Lehman, quoted by le Camus (Journ. de Physique, for March 1779, p. 183), speaks also of a similar *silver ore*, found in a mine of peat-coal. *The Editor.*

SECT. 267. (additional).

Native Silver, mixed, *or* alloyed, *with other metals*.

Native silver is seldom found pure, *viz.* by itself alone. The following are the known instances of these alloys:

1. Native silver, united to gold, *Bergman's* Sciagraphia §. 154. That which is found

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Native silver is found in various forms, as already mentioned, inhering either in *baro-selenite*, *lime-stone*, *selenite*, *quartz*, *chert*, *flint*, *serpentine*, *gneis*, *agate*, *mica*, *calcareous spar*, *pyrites*, *shistus*, *clay*, &c.

Also in separate masses of various sizes (some of the weight of 60 pounds) in or near the veins of most metallic substances, particularly in *Peru*, and frequently in various parts of Europe; either of a *white*, *brown*, or *yellowish* colour.

Sometimes it is diffused through *sand* and *ochre*; and also in grey *lime-stone* in the Lower Austria; and in a *greenish clay* near Schemnitz; or mixed with *ochre*, *clay*, and *calciform nickel*.

It is seldom found *pure*, being generally alloyed with *copper*, and sometimes with a small proportion of *gold*, *iron*, or *regulus* of *antimony*; and sometimes with about 5 *per cent.* of *arsenic*.

According to Henckel and other Mineralogists, silver, in the capillary form, and in thin scales, is produced by the decomposition of the *red silver mine*: and Wallerius asserts, that if sulphur is mixed in a small heat with silver, this last takes a capillary form.

At *Kungsberg*, and at *Sainte-Marie-aux-mines*, in Alsace, silver is found in the form of solitary cubes; and octoedral lumps, of 50 and 60 pounds weight, have also been found in the last of these two places. *Mongez.*

of

of this species near *Konigsberg*, contains so much gold, as to acquire a yellow colour from it. *Kirwan.*

2. Mixed with copper. *Berg.* Sc. § 155.
3. United to gold and copper. *Berg.* Sc. § 156.
4. Amalgamated with mercury, found in the mines of Salberg; as J. R. Foster notes to *Brunnick* [a].
5. United to iron. *Berg.* Sc. § 157. The iron in this ore seldom exceeds 2 *per cent*: but oftner it hardly amounts to $\frac{1}{100}$. *Mongez.*
5. United to lead, sometimes in such quantities, as to be worth the expences attending the separation [b].

6. United

[a] Mr. Romé de l'Isle, speaks of a native amalgam of silver and mercury, now in the French king's cabinet at Paris, which was found (at *Muschel Landsberg*, in the Dutchy of *Deux-Ponts*) in a ferrugineous matrix, mixed with cinnabar. This specimen is of a crystalline hexagonal form, and of a large size. See his *Crystallogie*, Vol. I. p. 420. See also the Sect. 287. of this Mineralogy. *The Editor.*

[b] Silver is always contained in lead, though it is generally in so small a quantity, that it is not worth the charges of separating it. Thus, accurate Essayers never fail of trying the lead they use in their coppellations, in order to account for the respective addition arising from it to the neat produce of metal that remains in the coppel. In the reign of Edward the First of England, near 1600 pounds weight of silver were obtained, in the course of three years, from a mine in *Devonshire*, which had been discovered towards the beginning of his reign, *viz.* about the year 900. The lead mines in *Cardiganshire* have, at different periods, afforded great quantities of silver. Sir Hugh Middleton is said to have cleared from

7. United to arfenic. Mr. Monnet found this ore among thofe from Guadanal canal in Spain, as may be feen in the fupplement to the *Journal de phyfique*, for 1778, page 50. The mine of *Samfon*, near *Andreaberg* in the *Hartz*, furnifhes this fpecies of filver. Mr. Mongez remarks, very properly, that thefe ores muft be diftinguifhed from thofe in which the arfenic is in the form of an acid; for in this cafe, they are properly mineralized by it; and fuch feem to be thofe of Sect. 170. 235. and 248. of the Author. (See Sect. 275.) Whilft there muft be only a mixture with the nanative *filver*, or with it's calces, if the *arfenic* be in it's *reguline form*.

8. Native filver united to antimony. *Berg.* Sc. § 159. This ore being roafted, gives out fome fmoke, but has not the fmell, fimilar to that of garlic, which arfenic gives out when burned.

from them 2000 pounds in a month. The fame mines yielded, about the year of the Rebellion (1745) *eighty ounces* of filver out of every *ton* of lead. The lead ores from *Brunghill* and *Skekorn* produced alfo a confiderable quantity of Silver. The lead only in one of the fmelting houfes at *Holywell* in Flintfhire, produced no lefs than 37521 ounces, or 3126 ¾ pounds of filver, from the year 1754 to 1776; and from 1774 to 1776. There are fome lead-ores in Great Britain, which, though very poor in lead, contain between 3 and 400 ounces of filver in a ton of lead; but it is not to be expected that the Proprietors fhould be forward in declaring it to the world. It is commonly obferved, that the pooreft lead-ores yield the moft filver; fo that a large quantity of filver is probably thrown away in England, from not having the pooreft fort of lead-ores properly affayed. *The Editor, from* Watfon's Effays, *Vol. the Third.*

9. Joined to the regulus of arſenic and iron. *Berg.* § 160. This ore is found in the mines near *Freiberg*, where it is called *White-ſilver ore.* Mongez.

The above three metallic ingredients are nearly in equal proportions.

All the ſpecies mentioned in this Section have metallic properties and appearances: the contaminating matters are ſometimes extremely ſmall; but not to be neglected, when they exceed $\frac{1}{300}$ part of the whole maſs. *Bergman*, ibid.

10. Native ſilver mixed with the alkaline lime-ſtone from Annaberg, deſcribed by Mr. Juſti, *Brunnich* [c].

11. Sandy ſilver ore, without any metallic ſhining.

11. Silver

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[c] Wallerius has formed a particular claſs of ſtony ſilver ores, which he diſtinguiſhes by the epithet *Lapidea*, and is the 397 ſpecies of his *Mineralogical Syſtem*: under this head he deſcribes the following varieties;

1. The *calcareous* ſilver ore (*argentum alkali mineraliſatum*, which ſeems rather an ambiguous denomination) found at *Annaberg* in Auſtria.
2. The *ſpathoſe*, or *ſparry* ſilver ore, which is either *white*, *variegated*, or *yellowiſh*, found at *Schemitz* in Hungary.
3. The *quartzous white* ore, in a powdery form, mixed with ferrugineous Scoria, found in *Potoſi.*

4 and 5. The *dark*, and the *variegated quartzous* ſilver ores.

According to this Author's deſcription, all theſe ores contain *native ſilver*, without any material difference, beſides the accidental colour, or the mixture of other earths.

It was alſo for the ſake of increaſing, as it ſeems, the number of theſe uſeleſs ſubdiviſions, that this celebrated Mineralogiſt formed his *Species* 398, containing the *dark-brown*, and the *yellow* ſandy ſilver ores; his Species 399 of the *ſcoriaceous*

2 native

12. Silver ore in a red-brown shistus, described by Lehman: it is composed of argillaceous earth, micaceous hematites, sulphur, calcerous spar, fluor mineralis, lead and silver. It contains about 7 or 8 ounces of silver on the hundred weight.

13. Soft silver ore. It is found among the marles and argillaceous earths, and is of various colours, either singly or mixed. It is somewhat simillar to the *goose dung silver ore*: and is found at Marienberg, Schemnitz, Huelgoet, in Brittany, &c. *Mongez.*

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B. Dissolved and mineralised, *Argentum mineralisatum.*

1. With sulphur alone, *Argentum sulphure mineralisatum.* Glass, or vitreous silver ore, *Minera argenti vitrea.*

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native silver ore; his Species 401, containing the following soft silver ores; *viz.* 1. The *ochreous* (or *margaceous*), variegated with *red*, *green*, and *yellow* spots, which is properly the ore that will be described in Section 282: 2. The *yellow*: 3. The *clayish*, unctuous to the touch: 4 and 5. The *solid* and the *porous* margaceous white ore: 6. The *argillaceous*; and, finally, the *copperish* ore, of a *green*, or *blue* colour; and his last article of *Minera argenti figurata*, found in some slates, which he had already described among the *copper ores*. The Editor.

This is ductile and of the same colour as lead; but, however, becomes black very quickly in the air [a]. It has, therefore,

[a] This kind of ore is found either in large lumps, or inhering in *quartz*, *gypsum*, *gneiss*, *pyrites*, &c.

It is of a *lamellar*, *granular*, or *capillary* form, or *crystallized*.

Though generally of a *lead colour*, sometimes it is *grey* or *black*, even when first broken.

It's lamina are not only ductile, but even flexible, and malleable to a certain degree; and so soft, that they may be cut with a knife.

Its specific gravity is = 7,2000.

100 parts of it contain from 72 to 77 of silver; and is rarely contaminated with other metal, except some small portion of iron.

It is found in *Hungary* near *Shemnitz*, and in *Saxony* near *Freiberg*, particularly in the famous mine of *Himmelsfurst*. Kirwan.

This ore seems to be nothing else but native silver, penetrated by *sulphur*; for on being exposed to a slow heat, this last flies off, and the native Silver remains in filaments. There are nine varieties of this ore;

1. Like *black-lead*, or *plumbago*, this is the most common of all.

2. *Brown*. Bruckman mentions one of this appearance, which was green in the inside.

3. *Yellow*. This colour is owing to some arsenic contained in it, which forms an orpiment with the sulphur,

4. *Greenish*.

5. *Blueish*. This is friable, like scoria of metals, and is called at Fryberg *Schlarckenerz*, ore of Scoria,

6. in form of *vegetations*.

7. *Lamellated*.

8. *Crystallized* into octaedral, or hexaedral prisms, and into decaedral pyramids.

9. *Superficial*; viz. covering the stones, or masses of other ores. *Mongez*.

But Wallerius, by subdividing some of these varieties, has added *two* more to this number. *The Editor*.

undeservedly

undeservedly got the name of *Glass-ore*; for that name rather belongs to the *minera argenti cornea*, or *horn-silver ore*, if indeed any silver-ore can be considered as *glassy*.

It is found in the same manner as *native gold*, viz.

1. In crusts, plates, or leaves.
2. In the form of
   a. Snaggs, and of
   b. Cristalline figures.

It is generally either of a lamellar or a grained texture, and is found in Kongsberg and in the Saxon mines, [b].

The *glass-silver ore* is the richest of all silver-ores; since the sulphur, which is united with the silver in this ore, makes out but a very small quantity of its weight [c].

[b] The Hungarian *glass silver-ores* are now scarce; some are now and then found in the wind-shafts, which are very frequently covered with a thin membrane, or rather crust, of the colour of pyrites. *Brun.*

[c] It contains about 180 marks of silver in the hundred weight. The medium between the *glass ore* and the *red gilder-ore*, is called *Rosch-Gewaechs* in Hungary, and *brittle glass-ore* in Saxony. It is of a black colour, and, when pounded, gives a black powder. In the mines of *Himmels-furste* near Freiberg, it is said to have held 140 marks, but these pieces are very scarce at present. It sometimes shoots into dendritical figures, between the cubic lead-ore, at a mine called The *Old Green Branch* near Freiberg. *Brunnich.*

SECT. 269. (Additional.)

Arsenico-martial silver ore, *Weill ertz* in Germ.

This ore contains *silver* and *iron* mineralized by *arsenic*: this last is in a larger proportion than the *iron*. This is the *Pyrites argenteus* of Henckel.

1. It is a hard substance, of a white shining appearance, and of a compact, lamellar, or fibrous texture.

The brightest has less silver, this only gives 6 or 8 ounces per quintal: and the richest gives about *ten* per centum. It contains no sulphur.

It is found in *Saxony*, the *Hartz*, at *Guadanal-canal*, &c. *Kirwan*, *Spec.* 7.

2. Of a yellowish-white colour, and of a striated structure, resembling *bismuth*, but much harder.

It melts very easily; and, if kept in fusion, it loses it's arsenic, and the silver remains almost intirely pure, as it contains but very little iron.

It produces about 60 *per cent.* of silver.

It is found near *Guadanal-canal* in Spain. *Kirwan*, *Spec.* 3.

3. Near the same place is found also another ore of the same kind; but the quantity of the arsenic in it is so great, that it would scarcely

scarcely deserve to be called a *silver ore*, if the arsenic were not easily dissipated.

It is very soft, and easily cut; and, when cut, has a brilliant metallic appearance. It consists of conchoidal laminæ.

The quintal contains only from 4 to 6 ounces of silver; but

It is easily reduced by evaporating the *arsenic* by fire, which then leaves the *silver* slightly contaminated with *iron*. Kirwan, spec. 4.

SECT. 270. (170.)

Red or Ruby silver ore. Rothgulden *in Germ.*

2. With sulphur and arsenic, *Argentum sulphure et arsenico mineralisatum. Minera argenti rubra*, The red or ruby-like silver ore. The *Rothgulden* of the Germans [a].

The

[a] This is a heavy, shining substance, either transparent or opake; mostly of a *crimson* or *reddish* colour, though sometimes it is *grey* or *blackish*.

It is found either in shapeless masses; or crystallized, in pyramids or polygons; or dendritical, or plated, or with radiated incrustations.

Its matrixes are either the quartz, flint, spar, pyrites, sparry iron-ore, lead-ore, cobalt ore, jasper, baro-selenite, gneiss, &c.

When radiated, or striated, it is called *Rothgulden bluth*.

It not only cracks in the fire, but detonates with nitre.

Its specific gravity is from 5,400 to 5,684.

The colour of this ore varies as the proportion of each of these ingredients varies in the mixture; viz. from dark grey to deep red; but when it is rubbed or pounded, it always gives a red colour. When put in the fire, it crackles and breaks; and when the crackling ceases, it melts easily, the arsenic at the same time exhaling in smoke. [b].

a. Grey arsenical silver ore; which is either,
1. Plated, crusted, or leaved, and,
2. Solid.

b. The red arsenical silver ore,
1. Plated, crusted, or leaved,
2. Solid or scaly, and
3. Crystallised [c].

In

According to Bergman, it contains in the *hundred*, 60, and sometimes 70 of silver, 27 of arsenic, and 13 of sulphur.

The darkest coloured ores of this kind are the richest; and these often contain some little iron. The yellowest are the poorest.

But the most yellow do not belong to this species, being, in fact, an *orpigment*, containing 6 or 7 per cent. of silver. *Kirwan*, Sp. 5.

This last kind is called *Rosi-cler* by the Spaniards. It comes chiefly from *Potosi* in America. *Mongez.*

[b] Red gilder-ore, if very well pounded, or ground, turns of a *dark colour*: cinnabar, under the same circumstances, becomes of a *bright red*: and orpiment grows *yellow*. But their crystalline appearance can easily be mistaken. *J. R. Foster.*

[c] Wallerius mentions the six following varieties of this notable ore, in his Species 388; *viz.* 1. The *red opake*, like cinnabar from Andreasberg in the Hartz, and from Salberg in Westmannia: 2. The *blueish* from Freiberg and Annaberg: 3. The *grey* from Freiberg and Andreasberg: 4. The *red transparent*

In this last form it shews the most beautiful red colour, and is often semi-transparent. It contains about sixty per cent of silver; and is found in the greatest quantity at Andreasberg in the Hartz [d].

SECT. 271. (part of Sect. 171.)

Mineralized by sulphur, *little* arsenic, *and* iron. *Schwartz ertz, Schwartz gulden, Silber mulm.* in Germ.

It is a friable, withered, decayed ore.

a. Of a *black* or sooty colour, and is therefore called by the Germans *Silberschwartz*, or Russigtes-ertz [a].

SECT.

parent amorphous, of the garnet colour, from *Potosi* and Joachimstal: 5. The red transparent, crystallized into prismatic decaedres, or dodecaedres, from *Hungary*, *Alsace*, and the Duchy of *Deuxponts*: 6. The *only superficially red* ore, from Salberg, and *Ehrenfriederichsdorf*. The Editor.

[d] The places where this ore appears very frequently, are *Cremnitz* in *Hungary*, *Joachimsthal* in *Bohemia*, and the *Andreas mountain* on the *Hartz*; and each of these can be distinguished by the different crystallizations. A peculiar variety has been found near *Ehrenfriedersdorf*, in a silver-vein, where it crosses the tin-veins at Sauberg. Some of them lose their transparency, especially in damp places. *Brunnich*.

[a] This ore was supposed, by the noble Author, to contain a good portion of copper, to which the black or brown colour was attributed. But later analysis of this substance, have shewn that there is no copper at all, as Mr. Kirwan asserts

SECT. 272. (171.)

Silver mineralized by arsenic *and* sulphur, *with* copper *and* iron.

3. With sulphurated arsenic and copper, *Argentum arsenico & cupro sulphurato mineralisatum.*

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serts in his Species 6, of which the following is the extract. This ore is either, 1. of a *solid* or *brittle* consistence (which distinguishes it from the *vitreous-ore*) and of a *glassy appearance* in its fracture.

Or 2, of a *looser* texture, and *sooty*, or *deep black* colour.

It is like moss, or thin leaves, lying on the surface of other silver ores, or of those of *lead* and *cobalt*, or in *clays*, *ponderous spar*, *gneiss*, &c.

This last contains about 25 *per cent.* of silver.

And the former contains at most 60 *per cent.* of silver.

They are found in *Dauphiné*, Hungary, and Saxony.

Wallerius, in his Sp. 390, mentions the following varieties of this ore; *viz.* 1. The *spongious* from Siberia; and from Freiberg, which last produces 50 *per cent.* of silver.

2. That in the *powdry* form, is very rich in silver.

3. The *lamellated*, of a black colour, at Johan Georgenstadt, Freiberg.

4. That in a *branched* and *dentritical* form, found in Lorraine; and

5. The *superficial*, of a black colour, found at Freiberg. *The Editor.*

In Hungary this has the name of *silver mulm*; it has been found at Wendish Leuten, near Shemnitz, in Hungary, and contains 8 lb. ¼ *per cent.* of a silver containing some gold. *Brunnich.*

Minera

Minera argenti alba, the *Weissgulden* of the Germans [*a*].

This, in its solid form, is of a light grey colour, and of a dull and steel-grained texture. The more copper it contains, the darker is the colour. It often holds seven pounds of silver per *cent* [*b*].

N. B. The Schwartz *silver-ore of the last Section was inserted by the Noble Author in this place. The Editor.*

Its texture is solid, of a light grey colour, and is that sort properly called *Weissgulden*.

It is found at St. Mary among the mines in Alsatia, in the Saxon mines, and at St. Andreasberg in the Hartz [*c*].

[*a*] Mr. Kirwan says (Sp. 8.), that the *Weissgulden ertz*, or *Weissgulden* ore, is a heavy, soft, opake substance, fine grained, or scaly, bright and shining in its fractures, of a *whitish*, *steely*, or *lead-colour*; sometimes crystallized in a pyramidical or cylindrical forms; but often in amorphous grains; or resembling moss, or in the form of thin laminæ incrustating other bodies, found in quartz, spar, stellstein, pyrites, blend, lead-ore, cobalt-ore, sparry iron-ore, fluors, &c.

It is very fusible.

Its specific gravity is from 5 to 5,300.

Its proportion of silver from 10 to 30 *per cent*.

It is found, though not commonly, in *Saxony*, *Hungary*, the *Hartz*, and *St. Marie aux Mines*.

[*b*] This product of the Weissgulden, being so considerably less than what Mr. Kirwan mentions in the last note, justifies the errata, pointed out in Dr. Lewis's copy, in which 10 *marks*, of 8 ounces each, are put instead of the *seven pounds* of silver per cent. as mentioned in the text. *The Editor.*

[*c*] I have found crystallized white gilder-ore at *Clausthal* in the *Hartz*, and in *Transylvania*; the last holds above thirteen marks of silver, containing some gold. *Brunnich.*

SECT. 273. (172).

4. With sulphurated arsenic and iron, *Argentum ferro et arsenico sulphurato mineralisatum.* The *Weisertz*, or *white-silver ore* of the Germans.

This is an arsenical pyrites, which contains silver; it occurs in the Saxon-mines, and so exactly resembles the common arsenical-pyrites, as not to be distinguished from it by sight alone; or without other means.

The silver it contains, may perhaps consist of very subtile capillary silver [a] mixed in it.

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[a] Though our Author suspects that the silver in this ore may arise from subtile capillary silver mixed in it, yet it has not all the appearance of it. It is very scarce, and found with *mispickel* and *plumose silver-ore*, at *Braunsdorf* near *Freiberg*.

There is likewise a *brown mulm*, resembling rags, between and upon the cubic lead-ore, found at the *Dorothea-mine*, in *Clausthal:* this contained a great quantity of silver, but has not yet been tried for any thing else. *Brunnich.*

This ore has a solid and hard consistence, is granulated, and its colour is whitish and shining; it strikes fire with the steel, and discloses then that the arsenic enters into its mass, by a kind of garlic smell; sometimes it contains *native silver*, and this sometimes *is mineralized.*

It is found not only in Clausthal, but at Andreasberg, Braunsdorf, and Allemont, in Dauphiné. *Mongez.*

N. B. This ore is very different from that of Sect. 269. in which, according to Monnet, quoted by Kirwan, no sulphur is contained. *The Editor.*

However,

However, I have not had an opportunity to examine this circumstance.

SECT. 274. (173.)

5. With sulphurated antimony, *Argentum antimonio sulphurato mineralisatum.*

a. Of a dark-grey, and somewhat brownish colour.

The *Leberertz* of the Germans; from *Braunsdorff* in *Saxony.*

b. Of a blackish blue colour.

1. In form of capillary cristals, *Minera argenti antimonialis capillaris.* The *Federertz* of the Germans, or *plumose silver ore* [b].

It is found in Saxony, and contains only two or four ounces of silver per cent.

SECT.

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[a] There is a *brown-silver*-ore, called Leber ertz also, by the Germans, which contains *arsenic*, and *regulus of antimony.*

The colour of this ore is of a reddish brown, sometimes dark grey. It is found also crystallized into pyramids: but for the most part it is amorphous.

When scraped it appears red.

It contains from 1 to 5 *per cent.* of silver.

The greatest part of this ore is copper, and the next in proportion is arsenic. *Kirwan,* Sp. 10.

The copper in this ore amounts to 24 in the *hundred.* It is found at Dal. *Berg. Sciag.* 170. in Transylvania, and lately at Altheire in Grenada of Spain. This was of a hard solid consistence, and of a greyish blue. *Mongez.*

[b] Sometimes it contains a mark, *i. e.* half a pound of silver *per centum.* It is likewise found sometimes to contain a very trifle of silver only. *Brunnich.*

There

SECT. 275. (Additional.)

Silver, with iron, arſenic, and cobalt, mineraliſed by ſulphur.

This ore looks like the *Weiſſgulden*, (Sect. 272), excepting that the cobalt, by its decompoſition, gives it a roſy appearance. There are two varieties of this ore; one of a dull, tarniſhed ſurface, and of a ferrugineous look.

The other variety has a ſhining appearance, like the fracture of the ſilver-grey ore of the preceeding Sect. 274.

This ore produces ſome times 10 *per cent.* of ſilver. It is to this ſpecies of ores, that the *ſilver gooſe-dung ore* belongs. *Berg.* and *Mongez.*

It is diſtinguiſhed by the roſe-coloured particles of cobalt, diſperſed through a *dark brown*, *blackiſh*, or *grey*, and ſometimes *ſhining* ſolid maſs.

It is found in *Saxony*, and at *Allemont* in *Dauphiné.*

There is another ore called *Leberertz*, in Germany, which contains *arſenic* beſides the *ſulphur*; and the antimony is in a reguline ſtate. This ore, in point of colour, varies from a *dull white* to *grey*, *dark blue*, *brown*, or *black*.

It is found in a capillary form, or like wool, ſometimes looſe, at another time *attached*. Its filaments are rigid and inflexible. The whiter it is, the richer; but it ſeldom contains *one per cent.* of ſilver. *Kirwan*, Sp. 11.

It

It contains about 40 or 50 *per cent.* of silver, and very little cobalt. The arsenic is in an acid state, and united to the cobalt. *Kirwan, Sp.* 12.

SECT. 276. (174.)

6. With sulphurated copper and antimony, *Argentum cupro & antimonio sulphurato mineralisatum.* The Dal *Fahl-ertz* [a].

This resembles, both in colour and texture, the dark-coloured *Weissgulden*, or *Falertz.* When rubbed, it gives a red powder.

a. Solid.

b. Cristallised, is found in the parish of *Aminskog*, in the province of *Dal*; and at that place has been for several years melted by a method invented for the

[a] There is another like the above, under the same name, which contains arsenic, besides the orher component parts.

This is a hard grey, or dark grey ore, more or less brilliant; sometimes crystallized, but mostly amorphous. In fact it is the *grey-copper ore* (of which in its place) impregnated with silver, which it contains from 1 to 12 *per cent.* and from 12 to 24 of copper, the remainder being sulphur and arsenic, with a little iron. The richer it is in copper, the poorer it is in silver, and reciprocally.

Mr. Monnet remarks, that wherever copper is united to arsenic, silver is also found.

This is the commonest of all the silver ores. *Kirwan.*

Another variety of this ore has been found at *Schmitz*, which contains some gold, besides the silver. The grey-silver ore is sometimes black, and is called *Schwartz guldenertz*, by the Germans, and *Negrillo* by the Spaniards. *Mongez.*

different

different mixture of the ores; which process must be very troublesome to those who are not perfectly well versed in metallurgy.

It contains thirteen ounces of silver, and twenty-four per cent. of copper.

SECT. 277. (175.)

7. With sulphurated zink, *Argentum zinco sulphurato mineralisatum.* The *Pechblende* of the Germans.

This is a zink-ore, mock-lead, or blende, which contains silver, and is found among rich silver and gold ores; for instance, in the Hungarian and Saxon mines.

a. Of a metallic changeable colour.

1. Solid, and with fine scales.
2. In form of balls. The *Kugelertz*, or *Ball-ore.* It is found at *Shemnitz*, and contains also gold. Its yield of silver is twenty-four ounces per cent. and thirty per cent. of zink [*a*].

b. Black *mock-lead*, or *blende*, found in Saxony. This is also found,

1. Solid, and in fine scales;
2. And in form of balls.

[*a*] At present they know nothing of the *globular blend*, and *globular-ore* there. In Bohemia, near *Joachimsthal*, there is a *black-blend*, which is very heavy, and whose surface is elevated, like some kinds of *hæmatites*, but they have not been able to get any silver out of it. *Brunnich.*

SECT.

SECT. 278. (176.)

8. With sulphurated lead. Potters ore. *Galena.* Bleyglanz, *Germ.* (*See Sect.* 188. *of the Author.*) [*a*].
9. With sulphurated lead and antimony, called *Striperz.* (*See Sect.* 190. *of the Author*).
10. With sulphurated iron, *argentum ferro sulphurato mineralisatum.* *Silberhaltigerkies*, marcasite holding silver [*b*].

At *Kongsberg*, in Norway, it is said, a *liver-coloured marcasite* is often found, particularly at a mine called *Fraulein Chistiana*, &c. This marcasite contains of silver, from three to three ounces and a half *per cent.* [*c*].

[*a*] This ore is called also *Pyritous Silver.* It is of a brown colour. It produces a very small portion of silver: and it is found at Kungsberg in Norway. *Mongez*, § 164. A.

[*b*] This ore produces *half an ounce* of silver *per cent.* There are great varieties of this ore, and many produce a considerably larger quantity of silver. *Berg. and Mongez.* § 165.

[*c*] The Hungarian *gilf*, which contains gold and silver, will doubtless be found to contain some iron, though its constituent parts are not yet sufficiently examined.

11. With sulphurated and arsenical cobalt. *Argentum cobalto sulphurato & arsenicato mineralisatum.* Is found at *Morgenstern* near *Freyberg* and *Annaberg.* Sometimes there are *dendrites* in the stone. These kinds generally wither in the air, and lose the silver they contain. In water they keep very well. *Brunnich.*

SECT. 279. (Additional.)

Silver mineralized by *Sulphur*, with *Regulus of Antimony* and *Barytes*.

The Butter-milk Ore.

This is found in the form of thin particles, on granular Spar. *Kirwan*, *Sp.* 13.

Perhaps is the same described by Wallerius, p. 346. of his second volume, by the words *lutosa*, *obscura*, *pinguis*. He says, that this ore is soft like *mud*, and feels like *butter*; and suspects to be produced from other silver-ores, which are washed away by the running waters. Bomare adds, that the miners look upon it as a certain sign of being arrived in the vicinity of the rich ore; but some others are singularly persuaded, that it is a green or unripened silver-ore, which will soon become a perfect ore, &c. *The Editor.*

SECT 280. (Additional.)

Combustible Silver-ore.

This is a black and brittle substance, and leaves about 6 *per cent.* of silver in its ashes. It is in fact a coal, in which silver is found. *Kirwan*, *Sp.* 14. Lehmann speaks also of silver found in coal-matrices. *Journ. de Physi.* for March 1779, p. 183.

SECT.

SECT. 281. (177.)

The Horn-silver-ore.

12. With the acid of common salt, *argentum acido salis solutum et mineralisatum. Minera argenti cornea.* Hornertz, or *Horn-silver-ore* [a].

This is the scarcest silver ore; it is of a white or pearl colour, changeable, or varying on

[a] It is sometimes found in snowy cubic crystals, of which the academy at Freyberg have a fine specimen. In 1747, were found many pieces of it at *Ober-Schöna. Brunnich.*

This scarce and valuable ore is either of a *white*, *grey*, *pearly*, or yellow, green, brown, purple, and black colour. Its principal character is its change into a *violaceous* brownish colour, when exposed to the Sun's beams, as it happens also to the artificial *horn-silver*.

It is frequently crystallized in a cubic form; sometimes it resembles an earth, easily fusible without smoke: the black sort is friable, and easily pulverised; but the other sort is in some degree malleable, may be cut with a knife, and takes a sort of polish when rubbed.

The *vitreous-ore*, which is sometimes mixed with the *black-horn-silver*, is soluble in nitrous acid; and may, by that means, be separated, the saline only being insoluble in that acid.

When the horn-silver is pure from iron, it contains 70 *per cent.* of silver at least; but these ores mostly contain some portion of iron, of which some is even united to the marine acid, according to Monnet.

This ore is found in *Bohemia*, *St. Marie aux Mines*, *Siberia*, *Allemont* in *Dauphiné*, *Johan Georgenstadt* in *Saxony*, *Guadal-canal* in *Spain*, and in *Peru*.

on the surface, semi-transparent, and somewhat ductile, both when crude, and when melted. It cannot be decomposed without some admixture of such substances, as attract the acid of the sea-salt. It is found in very thin worked or wrought leaves or crusts, at *Johan Georgenstadt*, in *Saxony*.

SECT. 282. (Additional.)

Silver Goose-dung ore.

This is of a greenish colour, mixed with yellow and red. It is said to contain about 6 *per cent.* of silver. Some think it a mixture

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It was first essayed by Mr. P. Woulfe. *Phil. Transact. for* 1776, and afterwards, though less exactly, by Mr. Monnet.

Mr. Woulfe was the first who discovered in this ore the presence of the vitriolic acid.

Professor Bergman, in his *Sciagraphia*, § 162. mentions another kind of horn-silver, mineralized by the *vitriolic* and *muriatic* acids, and *sulphur*. He doubts whether this be a different species of ore, since the sulphur and the salt scarcely admit of any other than a mechanical union. But since iron is often found, though in a small quantity, in these ores, it may form a marcasitical mixture therewith. Mr. Mongez asserts, that iron is certainly contained in the *horn-silver* ore that is found in Saxony, which is the impurest of the kind. But Wallerius, in his usual way, contents himself with distinguishing, by the external appearances of colour, the three following varieties; *viz.* the *whitish* horn-silver, found in *Zellerfeldt*, and in *Guadalcanal*; the *yellowish-brown*, which resembles *colophony*; and the *purple-green* found at *Georgenstadt* in Saxony. *The Editor from* Kirwan, Bergman, Mongez, &c.

of

of red silver ore, and calx of Nickel. *Kirwan, Sp.* 16.

Every one may easily observe, that Wallerius, Bomare, Romé de l'Isle, and other mineralogists, have given various names to some *silver ores*, whose contents are not quite different from one another; so that it seems rather probable they have been led by a whim of nomenclature from which no useful information can be gathered by their perusal. *The Editor.*

SECT. 283. (Additional.)

Foliaceous Silver ore. *Silberartiges, Bergzunder. Blatter erez.* in German.

Its colour is *mortdoré.* Some think it to be a *native silver ore*; others take it to be a mixture of *galena*, *ochre*, and *silver*.

This ore is found sometimes in the Mountain-cork (Sect. 69), and is so light, that it may swim on water. It contains but *one ounce* of silver *per quintal. Kirwan, Sp.* 17.

SECT. 284. (178.)

Observations on the Silver-ores.

Silver may, perhaps, be found mineralised in the like manner with other metals than these here enumerated, such as with cobalt and bismuth; but having no certain knowledge of such mineralizations, I omit them here[a]. It would be worth examination, if in those mine countries where gold and silver are found in quantity, other ores do not contain a little of those metals, more especially when the particles of silver and gold have not been able to extricate themselves from the other minerals, and lie separate from them in the *fissures*, *veins*, and *shakes* or *wranks*, that is to say, in the hollow places in the mines.

Those silver-ores which are named from earth or stones, wherein the silver is found; as, for instance, in the *Goose-dung silver ore*, and the *Leberertz*; ought no more to be considered in a natural system than other distinctions which are used at mineral works, and are only names given to the ores, according to the several changes they undergo to make them fit for the melting process[b].

---

[a] Our author doubts whether silver is ever found mineralized with *cobalt* and *bismuth*; but the ores from *Schee-berg* and *Annaberg*, are convincing proofs of it.

Silver has also been found in an amalgama with quicksilver, in the mines of Salberg. *J. R. Foster.* See Note *a* to Sect. 267.

[b] Notwithstanding this well-founded observation of our Noble Author, many mineralogists have made long catalogues of ores, whose varieties only consist in mere accidental circumstances. Wallerius, in his Spec. 401. has made numerous articles of the different colours and earths, with which the silver ores are found; a small part of which have been seen in Note *b*, to Sect. 267. *The Editor.*

A mi-

A mineralisation of silver with alcali has been recently mentioned: it is said to have been found at *Annaberg* in *Austria*. But this discovery, which is made by a mine-master, Mr. Von Justi [c], requires an explanation, since the author, in his description, does not observe the necessary distinction between alcali and lime; and quotes the *horn-silver ore*, and the *luna cornea*, as proofs of his opinion; by which, however, his opinion seems rather weakened than confirmed.

SECT. 285. (179.)

Platinum Linnæi.

Platina. White gold. Platina del Pinto, or *Juan blanco* in Spanish.

This metal is a recent discovery of our times, and is described with great accuracy by Scheffer, in the Acts of the Royal Academy of Sciences at Stockholm, for the year 1752; as also by Dr. Lewis, in the Philosophical Transactions for the year 1754, vol. xlviii [a]. And though these two gentlemen agree

[c] The silver in the alcaline lime-stone of Mr. Justi, from *Annaberg*, is native, as appears when it is polished. *Brunnich.*

[a] Mr. Macquer says, that in the year 1741, our countryman, Mr. Wood, brought to England from Jamaica, some platina, which was said to come from *Carthagena*, in the Spanish

agree in the principal circumſtances relating to this metal, yet it is very plain by their deſcriptions, that neither of them knew any thing of the other's experiments. By theſe deſcriptions we are convinced of the reſemblance this metal bears to gold; and therefore we muſt allow it to be called *white gold*, though, both theoretically and practically, it may be diſtinguiſhed from gold by the following qualities.

1. It

Spaniſh Weſt India; and that he had made ſome good eſſays of it. That in the year 1744, ſome vague accounts were publiſhed of this ſubſtance by Mr. Ulloa, in the printed account of his voyage with the French academicians to Peru, for meaſuring a degree of the earth near the Equator; and that he (Mr. Macquer) had worked with Mr. Baumé on this new metal, for which purpoſe he quotes the Memoirs of the Academy of Sciences for the year 1758.

Alonzo Barba, a Spaniſh metalurgiſt, quoted by Bomare, ſpeaks of a mineral, called *Chumpi*, ſimilar to the Spaniſh emery, and found among the red and blackiſh gold and ſilver mines at *Potoſi* and *Choyaca*, in the Spaniſh Weſt Indies, which was preſumed to be the true *native platina-ore*. This emery was called *Gold* or *Silver Emery*, and is now extremely rare in Europe.

But the moſt ſatisfactory account we have of the mines of Platina, is that given in the *Journal de Phyſique*, for November 1785, under the ſignature M. L. It is at *Novita* and *Citara*, on the North of the Province of *Choco*, in the Spaniſh Weſt Indies, that platina is found, more or leſs mixed with particles of gold; when theſe are too ſmall to be picked out by hand, they are ſeparated by amalgamation with mercury, as commonly uſed in ſimilar caſes; and from this operation proceed thoſe little globules of mercury, found ſometimes with platina; but not that they be naturally found together. In fact, there is not in the whole Spaniſh America any other

 mines

1. It is of a white colour.

2. It is so refractory in the fire, that there is no degree of heat yet found, by which it can be brought into fusion by itself, the burning-glass excepted (see the Note p. 573). But, when mixed with other metals, and semi-metals, it melts very easily, and especially with arsenic, both in its metallic form, and in form of a calx or glass.

3. It

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mines of mercury, but at *Guancavelica*, in the Peru, at the distance of above nine hundred miles from *Choco*; and it is further confirmed, by observing, that no such globules of mercury can ever be discovered in those parcels of Platina brought to Europe, when some particles of gold are mixed with it; this last being the true state of the native Platina, such as it is found in the ground. These mines are of the secondary kind, being found in strata of loose earth, that have been washed off from higher grounds. But the primitive or original mines, where platina has been produced, have not yet been discovered in any part of the globe.

The quantity of gold particles, intermixed with platina, is sometimes so inconsiderable, that it is not worth the expences attending the amalgamation with mercury. Very often it contains, 2, 3, 4, and more ounces of *platina* in the pound of *gold*; and what is remarkable, both these metals are constantly of the same form.

Platina is always found in the form of very small particles, from the minutest sand size to that of a common pea; although this last is very seldom to be met with. The above M. L. says, that he had some native particles, or pieces of platina, which weighed from 15 to 20 grains; and adds, that on trying some of these between steel-rolers, in the presence of Messieurs Tillet and Darcet, at Paris, they were perfectly laminated, which evinces, that platina, in its native form, is malleable. The same Naturalist adds, that a native piece of platina was found nearly of a square figure, almost as big

as

3. It does not amalgamate with quickſilver by itſelf, but only by means of the acid of common ſalt after a long trituration. This metal ſeems therefore really ſeparated from gold by amalgamation, at thoſe places where it is found; and, without this quality, it would be very difficult to ſeparate it.

4. It is harder and leſs coherent than gold.

5. It is heavier than gold; and therefore the heavieſt of all bodies hitherto diſcovered. For though the ſpecific gravity of platina, in the hydroſtatical experiments made by Dr. Lewis, is found to be to water only as 17,000 or 1600; yet, when melted with

as a pigeon's egg, which was depoſited in the Royal Society, at Biſcaya, which muſt be the ſame, known by the name of *Baſcongada*, or the *Society of the Friends of their Country*. But the common ſize of the particles of native platina, hardly exceeds that of a millet corn; and almoſt every one is of an oblong form, very flat, round edged, with a ſmooth ſurface, and of a whiter colour than iron; but always intermixed with black ferrugineous ſand. Moſt of its particles are friable, and magnetic: thoſe which remain after the ſeparation, operated by means of the magnetic bars, ſtill contain about one-third part of iron, according to the experiments of the Count de Sickingen.

I had the opportunity of examining a large parcel of platina (about 72 pounds troy weight) brought from Spaniſh America, among which I found not only a great quantity of ferrugineous ſand, but many bits of vegetable ſtalks and ſeeds, and alſo ſome very ſmall red cryſtals, like rubies. Theſe laſt I ſent to Mr. Achard, the ingenious and celebrated chemiſt of Berlin, who tried them as far as their minuteneſs and ſmall quantity could permit; and concluded they were real rubies. *The Editor.*

other

other certain metals, its specific gravity has, by an exact calculation, been found to be considerably augmented, even so much as to 22,000 [b].

6. Dissolved in *aqua regia*, and precipitated

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[b] According to Mr. de Morveau, the specific gravity of platina, reduced to a metallic mass, by the process of M. de l'Isle, which is the same of Count de Milly, mentioned in the next note [d], is - - - - - - 10,0353

That of native platina in grains, according to the Naturalist M. L. above-mentioned, is - - - 15,6017

That which is not attracted by the load-stone, according to the same M. L. is - - - - - 16,2519

And that purified by the muriatic acid, according to the same Author, is - - - - - - 16,7521

But according to Morveau, *native platina* in grains, has the specific gravity of - - - - - 16,6870

According to our Author Cronstedt, it is - - 17,0000

According to Bergman in his *Sciagraphia*, - 18,0000

When reduced into a metallic mass, and well hammered, according to Morveau, it is - - - 20,1700

Finally, Dr. Withering mentions, that by some late experiments, made by Count de Sickingen, and published in German, by Professor Succow; the specific gravity of *pure platina*, seems to be - - - - - - - 21,0000

One of those specimens I received from the late Count de Milly, which he rendered malleable by the process hereafter mentioned, in Note [d], being nicely examined by Mr. Nicholson, in a very good hydrostatical balance, shewed its specific gravity to be, *in the temperature of* 60 *degrees of Fahrenheit's thermometer* - - - - 21,370

Another specimen of the same, which was not magnetic, being examined also by Mr. Nicholson, after it had been melted by Parker's lens, and well hardened with a hammer on the anvil, shewed in the same temperature, - - 22,700

Finally, Mr. Kirwan, p. 239, of his Mineral. says it to be 23,000 *The Editor.*

with

with tin, or with a solution of that metal, it yields no *purpura mineralis* [c].

Except

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[c] This metal is soluble in *aqua regia*, as is likewise gold: and in the muriatic acid, when dephlogisticated, which, in that state, dissolves every metal: and perhaps in the vitriolic acid also, when distilled upon manganese; no other acid acts upon platina, without its having undergone a previous calcination. But its precipitation, by volatil alkali, does not fulminate: neither does it produce a purple powder with tin, as our Author has observed.

The solution of Platina in *aqua regia*, is at first yellow, but when further loaded grows red, and of a proportionally deeper colour. Upon evaporation, crystals are formed of a deep red colour, frequently opake, but sometimes pellucid, very small and irregular, resembling angular grains, which, when washed, require far more boiling water, than gypsum does, for their solution.

A small quantity of vegetable alkali precipitates a different sort of octoedral crystals, soluble in water; and a larger quantity precipitates a yellow spongy powder insoluble in water, which is the calx of platina. This may be dissolved more or less in all the known acids.

The celebrated Margraaf denied, that the solution of platina could be precipitated by the mineral alkali; and Dr. Lewis confirmed this assertion, upon his own experiments. But Bergman found that by pouring a large quantity of its solution, and still better by employing the dry and spontaneously calcined mineral alkali, the genuine calx of platina was precipitated.

Platina is precipitable from its solution in *aqua regia*, by *salt ammoniac*, as our late learned chemist Dr. Lewis discovered; this is a property by which this metal may be easily distinguished and separated from all others.

Lime also, whether aerated or caustic, precipitates likewise platina from its solution, as well as the mineral alkali.

It may be purified from iron by reiterated coction in marine acid; solution in *aqua regia*, and precipitation by the purest sal ammoniac; for platina is not precipitable by the

Prussian

Except these, this metal has the same qualities as gold; but it cannot, on account of its refractorinefs in the fire, be worked off pure on the cupel, neither can it be worked with antimony; because, before it is rendered perfectly pure, it cools, grows hard, and retains always some part of the added metals [d]. It

Prussian (or *phlogisticated) alkali*, as all other metals are, nor by the solution of the *vitriol of iron*. By these two precipitants the mixture of any *iron* or *gold*, that may still remain in the solution of platina in *aqua regia*, may be first separated, before its being precipitated by the solution of salt-ammoniac, and the platina may then be had perfectly pure. *The Editor, chiefly from* Bergman *and* Kirwan, &c.

[*d*] Platina, when perfectly pure in its metallic state, says Dr. Withering, is not calcined by deflagration with nitre.

It does not admit of being hardened or softened, by tempering like steel or other metals.

It has been drawn into a wire of $\frac{1}{1940}$ of a line in diameter. This wire admitted of being flattened, and had more strength than a wire of *gold* or *silver* of the same size. *Withering.*

N. B. I suspect this to be the $\frac{1}{1940}$ of an inch, as no such wire as here mentioned can be made. *Editor.*

Platina is not fusible by the strongest fire, but melts in the focus of a strong burning lens.

I have seen at Paris, that the great burning lens, of which the late generous Mr. Trudaine made a present to the Royal Academy of Sciences of Paris, and whose cost amounted to about one thousand pounds sterling, only agglutinated its particles in 20 *minutes*. But Mr. Parker's burning-lens, in London, perfectly melted them in less than *two minutes*. This last burning lens is of solid *flint-glass*, about 3 feet diameter; but the French was made of two glass-curved-plates, of 4 feet diameter, and filled with about 40 pints of spirits of wine. I am told that this costly instrument has been lately broken by some accident or other. *The Editor.*

From

It is brought to us only in its native ſtate, in ſmall, irregular, rugged grains; and it is yet uncertain

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From conſidering the very intereſting experiments of the Count de Sickingen, I apprehend the following method, to obtain pure and malleable platina, will be found a good one.

Diſſolve the grains of native platina, that are leaſt magnetic, in *aqua regia*: precipitate the iron by means of phlogiſticated fixed alkali: then precipitate whatever elſe will fall, by cauſtic vegetable alkali: ſaturate the liquor with cauſtic foſſil alkali, and ſet it by to cryſtallize: the yellow cryſtals thus obtained, are to be hammered together at a welding heat, and the metallic parts will unite. *Withering on the* Sciagraphia of Bergman.

Platina, however, may be reduced otherwiſe to a malleable ſtate. The method which the late Count de Milly employed at Paris, and which whole operation he was ſo obliging as to do in my preſence, and at my requeſt, is as follows: 1ſt, he ſeparated all the ſand and other heterogeneous particles, by blowing them out whilſt the grains of platina were letting down from one paper to another paper. He put the metal in a matraſs, with 20 times its weight of *aqua regia* on a ſand heat; the next morning decanted it from a ſediment, compoſed of ſome whitiſh particles, of a metallic appearance, mixed with a blackiſh matter, which he told me was a molybdenic ſubſtance. He then mixed with it an equal quantity of diſtilled water: precipitated the platina by a ſolution of ammoniacal ſalt; and he filtrated the liquor through blotting paper; this, and the reſidue being dried in a plate over the fire, was put on a Heſſian-crucible, which he guarded within another larger crucible. This was covered with a teſt, and put on a blaſt furnace, till it was red hot, even to a white heat, during *half an hour*; he then opened the crucible, where I ſaw the metallic ſubſtance, like a filamentous maſs; this he preſſed down with an iron rod, whoſe end was formed into a flat button: he covered it again, and continued the fire for ten or twelve minutes; the crucible being taken out, the ſolid maſs was connected at the bottom: could be forged, and beaten, on the anvil with the hammer, into any form, like iron.

uncertain whether it is found naturally mineralised. The Platina is brought to Europe from

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iron. I have some small specimens of this metallic mass, which do not differ in colour from silver; and I have also some that was flattened between the rollers, and is very springy: all these are attracted by the load-stone: but on my exposing a bit of this bar of platina to the focus of Mr. Parker's burning lens, it easily melted, retained its perfect mallability, and lost its attraction to the magnet: while the buttons, that had been fused of the grained platina, by the same lens, were not malleable, but very brittle under the hammer.

The chemists of Dijon say, that they have fused, very easily, platina in a strong blast furnace, by means of their new flux, by which iron, and all other hard metals, may be fused also, to the great advantage, as Mr. Tillet has tryed on the calces of copper, from which he got five *per cent.* more than by the *black flux*, though helped by tallow. This new flux consists of 8 parts of *powdered glass*, one of a *calcined borax*, and half of *powdered charcoal*. But they do not say whether the platina, after being so fused, was perfectly malleable, and fit to be worked to any advantage.

Platina may be alloyed with all metals, and fused with them in various proportions; but these mixtures are not such as to offer any advantages, being either too hard, or so imperfect, as to shew a very coarse grain. That with gold seems the best of all.

It is said, that the Spanish miners in America, have the art of treating platina, with a small quantity of sulphur and arsenic, so as to melt it easily, for making various pieces of use, as *snuff-boxes*, &c.: but I never heard of such pieces being brought to, nor seen in Europe.

According to the above quoted Mr. Bomare, in his *Mineralogy*, platina is easily fused by means of sulphur or arsenic: but he does not say that he has seen the operation tried. And Mr. Macquer asserts, that this metal may be fused by the addition of *liver of sulphur*, as gold may also by the same means.

Mr. Achard, the famous chemist of Berlin, discovered an easy method of fusing platina, so that crucibles, and other utensils from the *Rio del Pinto*, in the Spanish West-Indies. *See Note* [*a*].

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utensils of this unalterable metal, may be made without great trouble, for chemical purposes. The Author communicated it in a letter he wrote to me on the 18th of February, 1784. It consists in mixing, with *platina*, an equal weight of *white arsenic* in powder, and as much of *salt of tartar*. The mixture is exposed in a crucible to the heat of a wind furnace: it soon fuses together; and being thrown on an iron plate, the metal, when cold, is very brittle; it is then pounded in a mortar; and, having prepared a proper mould of very refractory clay, it is filled with the metallic powder, and exposed to a violent fire of copellation, till the arsenic be entirely evaporated. By these means the metal remains in its metallic form, with the very figure of the mould. Mr. Crell has published this process in his *Chemical Journal*; and the same was inserted in *Journal de Physique*, for June 1786, page 456. Mr. de Morveau has given also an account of his experiments on this subject, in the Memoirs of Dijon for 1785, page 106, and says to have succeeded, by making, in this method, some improvements. He says, that the *arsenic* and *salt of tartar* produced an overboiling froth, which ran off from the crucible; and that the arsenical fumes were very troublesome. But my friend, Mr. Babington, has fused in my presence, and at my request, *two ounces of platina*, in a wind furnace, at the Laboratory of Guy's Hospital, observing with care the above directions of Mr. Achard; and there was not the least inconveniency of the arsenical fumes, these being immediately droven up the chimney, whenever the test or cover was taken from the crucible, to examine the going on of the operation; nor was there observed any overboiling froth, &c. A lump of the metal was produced by the first operation, which was of a fine grain; but very brittle. Mr. William Cooper undertook also this process at my request, and the event was the same; even after he urged the fire for above two hours, to the 162 degree of *Wedgwood's thermometer*, the brittle lumps only became harder, but by no means malleable, as by the above process of Count de Milly: and the same happened to another like lump of platina exposed by Dr. Pearson, to the greatest heat of his wind-furnace. *The Editor.*

SECT. 286. (216.)

Quickfilver, Mercury. *Hydrargirum, Argentum vivum, Mercurius.* Lat.

General properties of Quickfilver.

Mercury diftinguifhes itfelf from all metals, by the following qualities [a].

a. Its colour is white and fhining, a little darker than that of filver.

b. It is fluid in the cold, and divifible by the leaft force; but, as it only fticks to a few

[a] 1. It were almoft fuperfluous, fays Mr. Kirwan, to mention any other character of quickfilver, than its liquidity, to diftinguifh it from other metals. In regard to this property, Bergman obferves, that Mercury conftitutes one extreme among the metals, and Platina the other; fince it requires to be melted, only fuch a degree of heat, as is rarely wanting in our atmofphere, and boils at the 600 *deg.* nearly after lead melts. *See the* Table *at p.* 509. But, when the cold is increafed to the temperature, denoted by 40 degrees below *nought* both of Farenheit's and of the Swedifh thermometer, which both coincide in that point (fince 212 − 32, *or* 180 : 100 : : 32 + 40, *or* 72 : 40), this metal concretes like any other metal; becomes quite folid and malleable like lead. The accurate experiments, made by Mr. Hutchins at Hudfon's-Bay, on this metal, as related in the Philof. Tranfactions, for the year 1783, p. 303. have proved this fact beyond all controverfy. Mercury, in its common ftate therefore, as the fame Bergman pronounces (in his Treatife of *Elect. Attract.*) is to be confidered as a

 metal

few bodies, to which it has an attraction, it is said that it does not wet.

It

metal in fusion; and since, in its solid state, it is nearly as malleable as lead, it by no means ought to be placed among the semi-metals, otherwise every other intire metal should be considered as brittle, for none is maleable when in fusion.

2. Quicksilver is as *opake* as any other metal. Its *specific gravity* is the nearest to that of gold itself. Its *indestructibility* by fire, air, water, or other agents, and its *reducibility*, or power of recovering its metallic state, with all its former properties, by itself alone, in the fire, are as compleat as those of the *perfect metals*. Boerhaave had the patience, as Dr. Lewis says, of distilling *eighteen ounces* of mercury 511 times successively, and it was not altered in any degree; it only appeared to him a little more brilliant, heavy, and fluid, which surely depended only on a very compleat purification, as Fourcroy remarks. See note *b*, N° 5, to Sect. 296.

3. The same Boerhaave kept mercury in a constant agitation for many months; digested it, for upwards of 15 years together, in low degrees of heat, both in open and close vessels, by itself, and in conjunction with other metallic substances; and received from all his labours only this result, that mercury is not, by any of those means, to be changed at all, as the same Dr. Lewis observes.

4. It is true that mercury may be calcined by heat alone. For this purpose it is put into matrasses, with long necks and flat bottoms, that the mercury be there spread with a large surface and a small depth: the necks are drawn into capillary tubes, by the flame of a lamp with a blow-pipe; and their ends are left open, or broken, to leave a communication with the external air: the matrasses are then exposed to a boiling heat in a sand-bath for night and day: in about 15 or 20 hours, some *red powder* is formed, and seen swimming on the surface of the mercury; but the process is continued for weeks and months, to increase the quantity. This is wrongly called *Precipitate per se*, it being only a real metallic calx; and as such, cannot be formed without the communication of the external air. It is *specifically* lighter, though its *absolute weight* is increased by $\frac{1}{10}$ above that of the mercury employed in the calcination; and contains

c. It is volatile in the fire [*b*].

d. Its

contains the *pureſt air*, firſt diſcovered and named *dephlogiſticated*, by Dr. Prieſtley. But this very calx may be reduced again, like that of *noble metals*, into perfect running quickſilver, without the addition of any other phlogiſtic ſubſtance, notwithſtanding it is ſo fixed, that it may be expoſed to the moſt violent fire without loſs; and may even be vitrified, as Keir, the Engliſh tranſlator of Macquer's Dictionary, poſſitively aſſerts.

5. By a heat no greater than that of the human body, or even of boiling water, though continued for ſome years, only a ſmall portion of the mercury is converted into a dark greyiſh or black powder, called *Æthiops per ſe*. Conſtant triture, or agitation, produce the ſame effect in a far ſhorter time. This powder is alſo revived by heat, without any other addition. *See note* [*b*].

It is then evident, that there cannot be the leaſt heſitation for ranging mercury among *entire metals*, as Bergman, Cramer, Linnæus, Fourcroy, and other mineralogiſts have done. But the Academicians of Dijon (vol. I. p. 114.), and Mr. Kirwan (p. 227. of his Elem. of Mineralogy) claſſed Quickſilver among the *perfect metals*, to which opinion I very willingly ſubſcribe. Notwithſtanding the Noble Author had left it among the *ſemi-metals*, which I can attribute only to his modeſty, for not contradicting the moſt general opinion of his contemporaries; although he had expreſſed his mind rather to the contrary at the beginning of the Note [*a*] to Sect. 260. p. 506.

[*b*] The volatility of this metal is ſuch, that even in the temperature of the atmoſphere, little globules of mercury are ſometimes gathered from its emanations in the inſide top of the tubes of barometers. Mercury being incloſed in a ſtrong box of iron, and the joints well ſoldered together, was put on the fire of a furnace, to try whether it could be fixed according to the expectation of the alchymiſts: the event, however, ſhewed, that it was reduced into vapours of ſuch an expanſive force, that it exploded with the utmoſt violence, tearing the iron into pieces, and every thing it met with in its way. This happened in the laboratory of Mr. Geoffroi junior; and Mr. Beaumé was witneſs to the accident, as Mr. Macquer relates in his *Chymical Dictionary*. The Editor.

d. Its weight is next to that of gold, viz. to water, as 13,593 : : 1000 [*c*].

e. It attracts the other semi-metals and metals, and unites with them all, except *cobalt* and *nickel*, with which it cannot by any means yet known be made to mix. This union is called an amalgamation [*d*].

This

[*c*] The *specific gravity* of Mercury is found so variously estimated by different authors, that there is scarcely any ground to judge what is the fittest to be followed. *See Note* [*b*] *to Sect.* 296. The Editor.

[*d*] 1. The Chemists of Dijon look on the amalgamations of mercury with other metals, as real solutions, which all depend on the mutual attraction between two or more substances, exerted in the *dry way*, and quite similar to those which take place in the *humid* or *moist way*; there being no other difference between both, than the form and the application of the crucible, or of the alembic, appropriated to contain the substances during the operation, according to the intensity, or mildness of heat, and to collect the results, &c.

2. The great attraction that subsists between gold and mercury, has already been mentioned in Note [*l*] to p. 519. And it is from this great affinity, that the globules of Mercury lose their sphericity, if placed upon some metals, particularly gold, on which they spread themselves, like water upon moist bodies, as the late ingenious chemist, Dr. Lewis, remarked in a note to Neumann's Chemistry, p. 133, of the 8vo edition, vol. I.

3. Mercury unites with gold, and also with silver; less easily with lead; still less so with tin; very difficultly with copper; and most difficultly of all with iron, to which it seems to have insuperable repugnance, as Newmann asserts. Dr. Lewis says, however, that quicksilver, in certain circumstances, seems, in some small degree, to act upon iron. That a plate of tough iron, kept immersed in mercury for some days, became brittle. The same Author observed also, in his said Notes, p. 101. that mercury adheres to, and coats the ends of iron pestles, used in triturating certain amalgams of it with saline liquors;

This amalgamation, or mixtion of metallic bodies, according to the readinefs with which they unite or mix, is in the following progreffion, viz. *gold*, *filver*, *lead*, *tin*, *zink*, *bifmuth*, *copper*, *iron*, and the *regulus of antimony*: But the three latter, however, do not very readily amalgamate. The iron requires a folution of the vitriol of iron, as a medium to promote the union.

f. It diffolves in fpirit of nitre, out of which it is precipitated by a volatile alcali, and common falt, in form of a *white powder*; but, if a fixed alcali is ufed, a yellow powder or calx is obtained [*e*]. *g*. But

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liquors; and I found an iron wire, about one-tenth of an inch thick, very brittle, as if penetrated by the particles of the quickfilver, after I had ftirred it, with that wire, whilft boiling in the tubes of barometers, for fetting loofe fome bubbles of air that were fticking to their infide. *The Editor*.

4. It does not eafily take up bifmuth, or regulus of antimony, unlefs they are previoufly mingled with other metals, or difpofed to unite with it by particular managements. Bifmuth, neverthelefs, difpofes fome other metals, particularly lead, to fuch an intimate union with mercury, as to pafs along with it through the pores of leather.

5. If mercury is impregnated with one-*fourth*, one *eighth*, or even one-*twelfth* of bifmuth, it diffolves maffes of lead in a gentle warmth, without any agitation, or triture, comminution, or melting heat. Thefe laft experiments were repeated with fuccefs by Dr. Lewis. Boyle relates many curious preparations of mercury, by which it acquires very wonderful qualities, although fome have been attempted by others, but without fuccefs. *See* Neumann's Chemiftry, *above quoted*; *p*. 136. *Vol. I*. and Note [*b*] to Sect 296.

[*e*] 1. Mercury is diffolved with great rapidity by *nitrous acid*: the liquor is of a *greenifh-blue colour*, but lofes it afterwards, and becomes limpid. This folution, when made with-

g. But it requires a boiling heat to diſſolve it

out heat, is uſed as a teſt for the analyſis of mineral waters, and has different properties from that made with the help of heat. In the firſt caſe, ſays Bergman, very little phlogiſton is loſt, and the ſalt eaſily cryſtallizes, being *white*, and ſcarcely acrid. It is not precipitated by diſtilled water: but, by cauſtic vegetable alkali, it is precipitated of a *yellowiſh* colour; by mild alkali, the precipitation is *white*; by mineral alkali, it is *yellow*, but it ſoon grows alſo *white*; by volatile alkali, it turns to a *greyiſh-black colour*; by Glauber's ſalt, or by pure vitriolic acid, the precipitation is *white*, *granulated*, and in a *ſmall quantity*; nor, if this precipitant has been ſparingly uſed, does this colour appear in leſs than an hour: by muriatic acid, or common ſalt, the precipitation is alſo *white*, but in a *large quantity*, and in *curdles*.

2. But if the mercurial ſolution be put over a ſand-heat, it may be charged with a quantity of mercury, equal almoſt to its weight. According to the Chymiſts of Dijon, 10 ounces of nitrous acid may diſſolve 8 of mercury. The action of the ſolvent becomes ſtronger with the heat; emits great quantity of vapours: and if not taken from the fire, will be too far evaporated. Diſtilled water will precipitate from this ſolution a *white calx*, becauſe it is more dephlogiſticated, and the ſolvent is over charged with it; and the water changing the denſity of the liquor, diminiſhes the adheſion of the calx, as Fourcroy remarks. This *white* calx will turn *yellow*, if boiling water be poured on it. The vegetable alkali precipitates it of a *browniſh-yellow*, which, by degrees, aſſumes a *pale-yellow* tinge: the mild vegetable, and the mineral alkalies, produce nearly the ſame colour; though when this laſt is employed, the colour turns afterwards to *white*. The precipitation by volatil alkali is quite *white* alſo; that by the vitriolic acid is *yellow*; and finally, a copious *white mucilaginous matter* is the precipitate by the marine acid.

3. This ſolution by *nitrous acid* is very cauſtic; corrodes and deſtroys animal ſubſtances; when it falls on the ſkin, ſtains it of a deep *purple brown* colour, which appears *black*: the ſtains do not go off before the ſeparation of the epidermis, which

it in oil of vitriol [*f*].

h. It is not affected by the acid of common salt, unless it be previously dissolved by other

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which falls away in scales, or kind of scars. It is used in surgery as a powerful escharotick, and is called *Mercurial water.*

4. The same solution, by cooling, is susceptible of forming crystals, which vary from one another according to circumstances: for the most part they are like needles; are very caustic; redden the skin; and detonate when put on burning coals, provided they be dry. They are called *Mercurial Nitre*, which fuses, when heated in a crucible; exhales reddish fumes; assumes a deep *yellow colour*, which afterwards turns to *orange*, and at last to a brilliant *red:* in this state is called *Red Precipitate*, or *Arcanum Corallinum.* It must be made in a matrass with a gentle heat, if it is designed to be *corrosive* for Chirurgical purposes.

Mr. Bayen carried the detonation of *mercurial nitre* much farther. He discovered that 30 *grains* of this *substance*, when precipitated, either by the mild *volatil alkali*, or by *lime water*; or of *sublimate corrosive*, when precipitated by *distilled water*, and properly dryed, being mixed with 4 *grains* of *flowers of sulphur*, detonate in an iron ladle over the fire, with as great a report as that of a fowling-piece. See *Journal de Physique* for *May* 1779, *p.* 353. The Editor from *Bergman*, *Fourcroy*, *Neumann*, &c.

[*f*] The *vitriolic acid*, concentrated and boiling hot, seizes on mercury, and presently reduces it, if urged by heat, to a kind of *white* powder (*see note* [*a*] *to* Sect. 288.), which turns *yellow* by the affusion of hot water, but does not dissolve in it; this is called *Turbith Mineral*; but if cold water, instead of being hot, was poured in the white mass, the powder would not change its *white* colour into *yellow*, as was said above about the nitrous solution.

2. This solution of Mercury by the vitriolic acid, is accompanied with a remarkable phenomenon; which is, that the acid contracts a strong smell of *volatile spirit of sulphur*, a notable proof that part of the phlogiston of the Mercury had united therewith. *See the end of Note* [*a*] *to Sect.* 289.

other acids [g], in which case only they both unite with one another, and may be sublimed together: this sublimate is a strong poison.

i. It unites with sulphur by grinding, and then produces a black powder called *Æthiops*

3. It deserves notice, that though Mercury be more easily dissolved by *nitrous* than by *vitriolic acid*; yet, if this last acid be put into a *nitrous solution* of mercury, the metal will quit the *nitrous*, in which it was dissolved, and unite with the vitriolic acid.

4. If Mercury be rarefied by heat into vapours, and these meet with those of *marine acid* in the same state, a *corrosive sublimate* will be formed.

This metallic salt shoots into crystals pointed like daggers, which are the strongest of all poisons. But there are various other processes found in Chemical Authors, to make this salt with more or less trouble.

5. If *corrosive sublimate* be mixed with tin, and distilled, a very smoaking liquor is produced, called by the name of its inventor, the *smoaking liquor of Libavius*.

The muriatic acid in the *sublimate* is not saturated, and from hence proceeds its great corrosive power; for if a fresh quantity of mercury be added to it, and sublimed a *second* and *third* time, a *sweet*, or mixed *sublimate*, called *Mercurius Dulcis*, and *Aquila Alba*, is produced, which is not poisonous, and is given internally as a *purgative*, or an *emetic*, according to the dose.

This *Mercurius dulcis* may be rendered still more gentle, by being sublimed *nine times*: this being digested eight days with aromatic spirit of wine, and dried after the spirit is decanted, is called the *Panacea of Mercury*. The *Editor from Macquer's Elem. of Chemistry.*

[g] Muriatic acid does not act upon quicksilver, unless this last be previously deprived of as much phlogiston, as $\frac{74}{100}$ of the quantity contained in the *hundred* of silver, or of $\frac{80}{182}$ in the *hundred* of zinc. *See Bergman's* Sciagraphia, *and his Treatise* De Phlogisti quantitate. *The Editor.*

The

Æthiops mineralis [*b*], which ſublimes into a red ſtriated body, called *Factitious Cinnabar.*

k. The ſulphur is again ſeparated from the quickſilver, by adding iron or lime, to which the ſulphur attaches itſelf, leaving the quickſilver to be diſtilled over in a metallic form; but if a fixed alcali be uſed, ſome part of the quickſilver will remain diſſolved in the reſiduum, which is a *liver of ſulphur.*

[*b*] The Academicians of Dijon ſay, that the true proportion to make this æthiops, is that of *one* part of brimſtone with *four* of mercury. Fourcroy directs only 1 of *mercury*, with 3 of flowers of ſulphur, to be triturated, till the mercury is extinguiſhed. A black powder is then produced, which is the *æthiops mineral.* The combination is better effected, when the mercury is mixed with the fuſed ſulphur: by agitating this mixture, it becomes black, and eaſily takes fire: it ſhould be then taken from the fire, and the flame ſhould be extinguiſhed a little after, ſtirring the maſs till it becomes into ſolid clots. If this ſubſtance is expoſed to a great degree of heat, it takes fire, the ſulphur is conſumed, and a ſubſtance remains, which is of a violet colour when pulverized. This powder being put into matraſſes, till their bottom is red by the force of fire, is ſublimed after ſome hours, and artificial cinnabar is found in the top of the veſſels, cryſtallized into brown red needles.

Mercury divided, by means of a rapid and continual motion, as that of a mill-wheel, gradually changes itſelf into a very fine black powder, as already mentioned in Note [*a*], which is called *Æthiops per ſe*, on account of its colour, in order to diſtinguiſh it from this *Æthiops mineralis*, mentioned in the text. *The Editor from* Fourcroy, p. 446. *and* 479. *Engl. Edition*, Vol. I.

SECT.

SECT. 287. (217.)

Native Mercury.

A. Quickſilver is found Native, or in a metallic ſtate. *Mercurius Nativus*, or *Virgineous* [a].

This is found in the quickſilver mines at Idria in Friuli, or the Lower Auſtria, in clay, or

[a] Mines of quickſilver are very rare in the earth. According to the calculation of Hoffman, there is *fifty* times more gold got every year out of the mines, than mercury and its ores. Dr. Lewis, in his notes to Newmann (p. 154. of Vol. I. 8vo edition), ſays that Cramer ſuſpects, that Hoffman only meant 5 times inſtead of 50; but neither the Latin nor the Engliſh edition of this Author expreſſes ſuch a thought; on the contrary, he adopts the ſame opinion; and only adds, that mercury is much more frequently met with than is commonly believed; but being ſo volatile in the fire, it often flies off in the roaſting of ores, and eſcapes the attention of Metallurgiſts.

2. The moſt conſiderable mines of Mercury are; 1ſt, thoſe of Idria in Friuli, and Carinthia, belonging to the Imperial hereditary dominions of Auſtria: 2dly, Thoſe of Spain at *Almaden*, near *Sierra Morena*, in the province of Eſtremadura: 3dly, Thoſe of the Spaniſh America, at *Guancavelica*, in the kingdom of Peru: 4thly, To theſe I may add thoſe of Braſil, near *Villa Rica*, between *Morro das Lages* and that of *Saint Anna*, where I am told by a native of that country, that ſuch a quantity of cinnabar and of native running quickſilver is found near the ſurface of the earth, that the black ſlaves often collect it in good quantities, which they ſell for a trifling price to the

or in a black flaty lapis ollaris, out of which it runs, either fpontaneoufly, or by being warmed even in the hands.

It

the apothecaries: but thefe mines never have been worked out, nor any notice taken of them by the owners. The fame Brafilian told me befides, that gold naturally amalgamated with mercury, was alfo found in the neighbourhood of that place; and, what is more extraordinary, he afferted, that almoft all the gold mines of that country, are only worked out by fimply wafhing them with running water, after reducing into powder the hard ores, which are fometimes imbeded in quartzous and rocky matrices.

3. Neumann fays, that the mines of Idria have produced at the rate of 231,778 pounds weight of mercury *per annum*; but thofe of Almaden in Spain produce much more. The chemifts of Dijon fay, that their annual produce is about 5 or 6 *thoufand* quintals, or between 5 or 600,000 pounds weight. Only in the year 1717, there were more than *two millions* and 500 *thoufand* pounds weight, fent from them to Mexico, for the amalgamation of the gold and filver ores of that country.

4. Bomare afferts, that the annual produce of the mines at *Guancavelica*, amounts to one *million pounds*, which are carried by land to Lima, thence to *Arica*, and finally to *Potofi*, for the fame purpofe. The Imperial quickfilver, above-mentioned, is brought to Holland, and from thence to various other parts, the Dutch having entered into a contract with the Imperial government to be the purchafers of the whole.

4. Befides the *three* great mines of quickfilver, already mentioned in this Note and in the text, this metal is found likewife in various other parts of Europe; as thofe at Mufchel-Landsfberg, in the Dutchy of *Deux Ponts*, and in the *Lower Auftria*. It flows there from a *fhiftofe*, or *quartzofe matrix*; and is probably mixt with fome other metal, fince its globules are not perfectly fpherial, as Mr. Kirwan remarks. The mines of Friul are all in fimilar beds or ftrata. It is found likewife vifibly diffufed through maffes of clay, or very heavy

ftone,

It has ſeveral times been found at Herr Sten's Bottn, in the mines of Salberg, in Weſtmanland,

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ſtone, of a *white*, *red*, or *blue colour*: of this kind are the mines of *Spain*, ſome of *Idria*, and of *Sicily*.

Maſcagni, already quoted in the Note to p. 266, found *fluid quickſilver*, as well as *red cinnabar*, and alſo *mineral æthiops*, near the lake of *Travale*, in the Dutchy of *Sienna*: the quantity however ſeems to be ſo ſmall, as not to deſerve working. On the contrary, the following mines produce clear profits enough to be worth the attention of the owners: *viz.* thoſe at *Kremnitz* in Hungary; at *Horowitz* in Bohemia; at *Zorge* in Saxony; at *Wolfſtein*, *Stahberg*, and *Moëſchfeld*, in the Palatinate. Mercury is brought alſo from Japan in the Eaſt Indies; but the greateſt part ſold in Europe, as *Japan cinnabar*, is manufactured in Holland, as Neumann aſſerts.

5. *Native* or *virgin mercury* was formerly ſought for by Alchymiſts with great anxiety and expence from Idria, for their great object of making artificial gold. Many others, nearly as mad, have been particularly fond of the Hungarian cinnabar, ſuppoſing it to be impregnated with gold: and ſo far has this ridiculous conceit prevailed, as Neumann ſays, that not only the mineral *cinnabar*, *antimony*, and *copper*, but the very *vine trees* of Hungary, have been imagined to participate of that precious metal. Even within theſe ten years, a ſingular French chymiſt announced to the public, that he had found a conſiderable quantity of gold in the aſhes of all *vine-twigs* and *ſtems*, and in the reſiduum of *garden ſoil*, after incineration. I was then at Bruxelles, and my good natured friend, the late Mr Needham, then at the head of the New Academy of Sciences, in that capital of Brabant, was highly diſpleaſed at my want of faith on ſo advantageous a diſcovery. But I was told afterwards, that the Count de Lauragais demonſtrated the fallacy and non-exiſtence of the fact, to the full ſatisfaction of the Royal Academy of Sciences at Paris.

5. Another alchymical whim, was that of fixing, or reducing mercury into a ſolid ſtate, ſo as to be employed like ſilver. But all proceſſes and operations of this kind, ſays Neumann,

 if

land, and ſometimes alſo amalgamated with native ſilver. *See the next Section.*

SECT.

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if they have mercury in them, are no other than hard amalgams. When melted lead or tin are juſt becoming conſiſtent after fuſion, if a ſtick is thruſt into the metal, and the hole filled with quickſilver: as ſoon as the whole is cold, the mercury is found ſolid. According to Macquer, mercury expoſed to the fumes of lead becomes equally ſolid. And Maurice Hoffman, quoted by Neumann, gives a proceſs for reducing mercury, ſo coagulated, to a ſtate of malleability, by repeatedly melting and quenching it in linſeed-oil; ſo that a metal is thus obtained, which may be formed into *rings*, and other *utenſils*; but the caſe is, that the mercury is really diſſipated by the repeated fuſions, and nothing elſe is left, but the original lead or tin of this kind of amalgam: ſtill more ridiculous are thoſe, who, melting an amalgam of copper and mercury, with tutty, imagine the braſs that reſults, to be a production of the mercury; ſince this is diſſipated by the fire, whilſt the tutty, which is a kind of *cadmia fornacum*, and contains zinc, gives the yellow colour to the copper, as every one knows.

6. Wallerius, after mentioning the ſtrong ſoap leys, or cauſtic lexivium, and other methods for fixing mercury a ſolid ſtate, tells us very gravely, that, by means of a certain *gradatory water*, whoſe compoſition he affirms to have learned, with great labour, from the Treatiſe of Creuling *de Aureo Vellere*, he could make a coagulum of mercury whenever he pleaſed, of ſuch conſiſtency, that great part of it would ſuſtain cuppellation; but this pretended Adept has taken care not to diſcloſe to the reader, the proceſs to make that kind of miraculous water.

7. Lemery, Pomet, and others, lay down ſome external marks for diſtinguiſhing thoſe places, in which there are mines of quickſilver; namely, thick vapours like clouds, ariſing in the months of April and May, the plants being much larger and greener than in other places, the trees ſeldom bearing flowers or fruit, and more ſlowly putting forth their leaves, &c. But theſe

SECT. 288. (Additional.)

Quickſilver united to gold, or ſilver.

Hydrargyrum argento vel auro adunatum.

The ſtate in which mercury is found alloyed, or *amalgamed* with ſilver, according to the expreſſion uſed by Mineralogiſts, appeared to Sir Torbern Bergman to deſerve a particular place in the *Sect.* 217. of his *Sciagraphia.*

Our Author had already mentioned this combination at the end of the laſt Section: and Mr. Kirwan aſſerts, on the authorities of Monet and Lin. Von Gmelin, that in *Sweden* and *Germany* mercury has been found united to ſilver, in the form of a ſomewhat hard and brittle amalgam.

Romé de l'Iſle had a ſpecimen of this natural amalgam from Germany, which is imbedded in a quartzoſe maſs, and mixed with cinnabar, as Mr. Mongez aſſerts; and he adds, that in the *Royal cabinet*, at the *King's Garden at Paris*, is depoſited another fine ſpecimen of this mercu-

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These marks, ſays Neumann, are far from being certain. They are not obſerved in all places where there is quickſilver, and they are obſerved where there is none. In the Hartz-foreſt are ſeen abundance of thoſe cloudy exhalations, though not a grain of mercury is found there; to which may be added, that at Almaden in Spain, where ſo large quantities of quickſilver ores are found, no ſimilar indications are obſerved. *The Editor.*

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rial ore, which was found cryſtallized in the mine, called *Carolina*, at Muchel-lanſberg, in the Dutchy of *Deux Ponts*. The ſame Mr. de l'Iſle ſpeaks alſo very poſitively of a ſpecimen of *native gold* from Hungary, which ſeems to be a natural amalgam of *gold* and *mercury*. It is compoſed of quadrangular priſms, of a greyiſh yellow colour, and of a brittle texture. This ſpecimen is alſo in the *King's cabinet* at the *Royal Garden* at Paris. See his Note 344 and 345. p. 420. of the firſt volume of his *Criſtalographie*.

Mr. Kirwan, ſpeaking of the method of examining the purity of gold by the *moiſt way*, ſuppoſes, with Sir Torbern Bergman, that there are natural amalgamations of *mercury* with *gold* and *ſilver*: and Neumann obſerves (p. 154. of his firſt vol. in 8vo.), that ſometimes a mineral, containing gold or ſilver, is met with among mercurial ores, although this is a great rarity [a].

It is evident, therefore, from what has been ſaid in this Section, and to which may be added the amalgamation already mentioned in Note *a*,

[a] This obſervation, ſays Mr. Neumann (p. 155. of his firſt volume, 8vo.) ſeems to ſufficiently refute the opinion of thoſe who hold mercury to be an hypoſtatic principle, or ingredient in all metals. For if metals were, and continued to be, produced from mercury, we certainly ſhould, oftentimes at leaſt, diſcover one where the other is. Our Noble Author explains, in a very judicious manner, this old opinion of ancient Chymiſts. *See his* Sect. 220. (*the* 296 *of this edition.*)

a, N° 2, to the last Section, Note *f*, to p. 524, N° 3. to p. 526; and also by the following Sect. 292. that there naturally exist various ores of quicksilver, amalgamated with *silver*, *gold*, and other minerals, although they be but seldom met with.

It is very probable, that the extraordinary great specific gravity which is found in some specimens of running quicksilver, proceeds often from its being naturally amalgamed with gold. According to Boerhaave, it may proceed also from its being redistilled a great number of times. By the same reasoning we may suspect, that the smallest of the specific gravities of quicksilver proceed from its amalgamation with *silver*, *lead*, and other metals, and *semi-metals*, which, in spite of repeated distillations, may still preserve their union with it; and Boerhaave asserts, that after redistilling a great number of times the same amalgam of *quicksilver* with lead or tin, he never could perfectly free them, by this method, from one another. *See the last Article of his Second* Dissertation on Mercury, p. 139.

That Mercury is many times found amalgamated with lead, is easily evinced, by the process of Mr. Grosse, related in the Memoirs of the French Academy, and mentioned by Mr. Macquer in his *Elements of Chemistry*, p. 296. Chap. 6. in 12mo. of the fifth English edit. where the method of extracting mercury from some solutions of lead is described; but the same Macquer, in his *Chemical Dictionary*, p. 205. Vol. III. in 12mo. positively affirms, that though Beccher and Kunchel have given other processes for this extraction of mercury from lead: and although the method, indicated by Mr. Grosse, be easier than the other process; nevertheless it does not succeed, if the lead is quite pure, without any amalgamation with mercury. And Boerhaave has expresly made the same assertion, complaining of those Authors who affirm the contrary. See his Dissertation *de Mercurio*, p. 133. at the end of the second vol. of his Chemistry, of the Lat. edition 1732. *The Editor.*

SECT.

SECT. 289. (218.)

B. Mineralised, *Mercurius mineralisatus.*

1. With sulphur, *Mercurius sulphure mineralisatus.* Pure cinnabar, *Cinnabaris nativa* [a].

This

[a] Native cinnabar is of different shades, from yellowish to a deep red; and is found alone in hard, or in friable masses, either shapeless, or crystallized in *cubes*, and sometimes transparent. It is found also in very heavy *red*, or *brownish red* stones and sands; and intermixed with clay or stone, or interspersed through the ores of other metals, particularly those of *silver*, *copper*, or *martial pyrites*.

Its texture is either radiated, striated, scaly, or granular.

One *hundred* parts of cinnabar contain about 80 of *mercury* and 20 of *sulphur*; but artificial cinnabar contains a little more sulphur; and hence its colour is darker. *Kirwan.*

I have lately revived some quicksilver from native cinnabar, by mixing with it, after it was reduced into powder, an equal weight of iron filings, in a glass retort, and the loss amounted to nearly *twenty-one per centum*, whilst the artificial cinnabar revived in the same manner, lost 23,2 pounds in the *hundred*. The Editor.

It sublimes in close vessels; but is decomposed in open ones, and volatilized when sufficient heat is applied.

It is insoluble in *nitrous* acid, as Monet asserts, *p.* 313. of his Treatise on *Metallic Solutions*, edit. 1775.

Macquer says absolutely, that cinnabar is not attacked in the *humid way*, by any of the chemical solvents: the vitriolic acid, however, when urged by heat, may be said to calcine it, as will be mentioned hereafter.

Mineralogists reckon six varieties of cinnabar naturally found in the earth: 1. *Friable*, commonly called *flowers* of

 cinnabar,

This is of a red colour; and its specific gravity to water is as 7500 to 1000.

a. Loose or friable cinnabar, *Cinnabaris friabilis*, it looks like red ochre.

It is found in the Duchy of *Zweybruck* or *Deuxponts*, in Germany.

b. Indurated, *Minera Mercurii indurata*; solid cinnabar. Is of a deep red colour, and, with respect to its texture, is either,

1. Steel-grained, from *Siebenburgen*;
2. Radiated;
3. Composed of small cubes, or scaly, from Idria and Hungary; or
4. Cristallised,

a. In

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cinnabar, or *native vermillion*. It has the consistence of a very fine powder, and sometimes has a needle form appearance. It is found in *Idria*, in the Dutchy of *Deux Ponts*, at *Menidot* in *Normandy*: 2. *Striated*, in the form of *needles*, which are sometimes dispoſed into radiations from a common center. It is very brittle, and contains the greatest quantity of quicksilver. It is found at *Almaden*, in the Dutchy of *Deux Ponts*, and in *Transylvania*: 3. *Lamellated*, or in the form of leaves: it only differs by its figure from the preceding, and is found with it: 4. *Granulated*, of a dark red colour, often of a compact and solid texture: sometimes its colour is pale, like the peach-tree flowers. It is found at *Siebanburgen*, and at the above-named places: 5. the *Argillaceous* cinnabar, so called, on account of its mixture with clay, and fat earths; its form is lamellated, and is easily dissolved in water, on account of the earthy mixtures. It is found at *Idria* and *Wolftein*: 6. finally, the *Crystalized*, which is often transparent. *Mongez.*

Professor Brunnich, in particular, says also, in a Note to this Section, that some transparent pieces of cinnabar are found also in the mine near New-Mæerktel, in Carinthia.

The

a. In a cubical form; it is tranſparent, and deep red like a ruby, from Muſchlanſberg in Zweybruck.

The finer coloured cinnabrine ores are never worked for extracting the mercury, but employed as pigments; but they have been very injudiciouſly preferred to the more pure factitious cinnabar for medical uſes; as we ſeldom meet with any native cinnabar, that has not ſome mixture of earthy or ſtony matter, nor with two pieces that perfectly agree. In the ſhops three principal ſorts are diſtinguiſhed; *viz*. 1. in *maſſes* weighing from 1 to 6 and more ounces: 2. in *grains* prepared, by breaking the worſer maſſes, and picking out the beſt coloured bits: and 3. *waſhed cinnabar*, which is prepared by waſhing of the lighter impurities that are found in it.

No native cinnabar ſhould ever be employed internally as medicine, without being purified by ſublimation. I have never met with any native cinnabar, ſays Newmann, that did not leave on ſublimation a grey aſh or ſand, amounting, in different parcels, from one-*ninth* to one-*fifth* of the mineral employed: the reſiduum had no gold in it, although the colour of its ſolution and precipitate gave at the firſt ſight ſome expectation.

It is obſervable, ſays Newman, p. 157, of his firſt vol. in 8vo. that though vitriolic acid forms with mercury a lively yellow concrete, called *Turpeth Mineral*, and with the inflammable principle (the phlogiſtic ſubſtance) a *yellow* ſulphur: and although ſulphur itſelf forms with mercury a beautiful *red* cinnabar; yet the ſame vitriolic acid totally deſtroys this *red colour*, rendering it as *white* as milk. I repeated this curious proceſs juſt before I wrote this Note, and found that the *vitriolic acid* does not produce immediately the leaſt *change of colour* in common cinnabar; but being digeſted in a glaſs cup, over a ſtrong ſand heat, it ſoon turned as *white* as *cream*: and the vitriolic acid took the form of a ſtrong *ſulphureous* and *volatil* vapour, very ſuffocating and corroſive; emitting very piercing fumes for ſome time, which turned black the paper it was covered with, and deſtroyed its texture. *The Editor.*

SECT. 290. (Additional.)

Impure Cinnabars.

The three following mercurial ores deserve to be treated of in a separate place from the pure cinnabar of the preceding section.

1. A mercurial ore is found in Idria, says Gellert (p. 57. of Ed. 1776.), where the mercury lies in an earth or stone, as if it were in a dead form; and has the appearance of a red-brown iron-stone; but it is much heavier than that. It contains from 3 quarters to 7 eighths of the purest mercury; leaves, after distillation, a very black strong earth behind, and gives some marks of cinnabar. This mineral, however, seems not, with that particular property as already mentioned, to be called an *ore*; but may rather be placed to the *native mercury*. For as we do not know the ultimate divisibility of mercury, we cannot justly determine the point of its fluidity, although its globules may no more be discernible.

These are the words of this great Metallurgist; and had he not said, that this ore required a distillation to disengage the metal, it might have been ranged among the native quickfilver ores. Such as it is, it deserves to be noticed in this place. *The Editor.*

2. Liver

2. Liver ore, which is most common in Idria, and has its name from its colour. To all outward appearance it resembles an indurated iron-clay; but its weight discovers that its contents are metallic. It yields sometimes eighty pounds of quicksilver per hundred weight.

3. Burning ore. *Brand-erz* in German. This ore may be lighted at the candle; and yields from nine to fifty pounds of quicksilver *per* hundred weight. *Brunnich in his* aditions *to our Author's Mineralogy.*

SECT. 291. (Additional.)

Quicksilver mineralized with iron by sulphur. Pyritous Cinnabar.

Sir Torbern Bergman inserted this ore in the Sect. 177. of his *Sciagraphia*, and seems doubtfull whether this be a distinct species from the cinnabar; as the iron is perhaps, says he, only mechanically diffused therein. Mr. Monges remarks, that there are but a few instances of cinnabar in which iron is not found in its calcined form; though, in the act of the ore being reduced, it passes to its metallic state, and becomes capable of being acted on by the load-stone. But if there are pyritous cinnabric ores, as there is not the least doubt of their existence, they deserve to be ranged, in a separate section, by themselves.

Another pyritous ore of cinnabar was found at *Menidot*, near *St. Lo* in *Lower Normandy*. It consisted in grains of different sizes, of a red brown colour: they had a vitriolic taste, and a sulphureous smell.

Pyritous ores of this kind are found also at *Almaden* in *Spain*, and at *Stahlberg* in the *Palatinate*. The cinnabric pyrites of this last place are of a dodecaedral form. *The Editor from Bomare's* Mineralogie, *vol.* 2. *p.* 166.

SECT. 292. (Additional.)

Quicksilver mineralized with silver by the aerial acid, and sulphur.

This seems to be a native precipitate *per se* or calx of mercury. It is said to have been lately found in Idria, in hard compact masses of a brownish-red colour, &c. Mr. Kirwan extracted a part only of this article from the *Journal de Physique* for January 1784, p. 61. I will, however, transcribe a fuller account of this article, as it seems to afford some further information.

This ore looks as a calciform mass, of a solid and hard texture. It is of a brown-red colour on the outside, but of a red colour in its fracture, which is granulated.

Various

Various little globules of mercury were contained in its pores, which are rendered viſible by being heated, but are ſoon rè-abſorbed by cooling.

Expoſed in an iron-ſpoon to the fire, the red colour became more vivid; but by cooling, it turned yellowiſh.

Diſtilled in a pneumatic apparatus, a quantity of *dephlogiſticated* air was produced, though leſs by a fourth part than an equal bulk of common cinnabar ſhould produce; and about *ninty-one* parts *per centum* of running *quickſilver* were revived.

One ounce of this ore being diſtilled in a glaſs retort, a little *yellow powder* was left, which weighed ¼ of a *grain*, and ſtained the bottom of the retort, as the calx of ſilver generally does on white glaſs in ſimilar circumſtances. This powder being ſuſpected to be a *calcined ſilver*, was cuppelated, with 144 grains of *lead*, after being wrapped up in a paper, in order to offer the phlogiſton of the burned paper to the later. After incandeſcence, the increaſed weight of the lead, over that of the teſt of compariſon, proved that the calx was reduced into its metallic ſtate of ſilver, and mixed with the lead.

If this account can be relied upon, it will prove, that quickſilver, even in a calciform ſtate, is naturally found mineralized with ſilver, by means of ſulphur. *The Editor.*

SECT. 293. (Additional)

Pyritous Mercurial Ores, with Silver and other Metals.

Mr. Monet, in his Sp. 77. relates, that he found in a metallic ore brought from *Dauphiné*, in 1768, by Mr. de Montigny, the following contents. This ore is of a *grey*, or *whitish* colour, and *friable*. On being analyzed, one *hundred* weight of this ore afforded $\frac{1}{100}$ part of *mercury* and 4 or 5 ounces of *silver*.

The remainder was *iron*, *cobalt*, *arsenic*, and *sulphur*. *See his Mineralogy*, p. 392, *quoted by* Mr. Kirwan at *p.* 312, and *by* Mr. Mongez, §. 178. B.

Cinnabar, mixed with *arsenic*, or *realgar*, is said to be found in *Japan*, according to Lin. Von Gmelin, quoted by Kirwan, *ibidem*, p. 312,

At Morsfeld *cinnabar*, and the white calx of *arsenic*, present themselves in the same rock. Kirwan, *ibidem*.

SECT. 294. (219.)

Quickfilver mineralized, with fulphur and copper.

Mercurius cupro fulphurato mineralifatus.

This ore is blackifh grey of a glaffy texture, and brittle; crackles and fplits exceffively in the fire; and when the quickfilver and fulphur are evaporated, the copper is difcovered by its common opaque red colour in the glafs of borax, which, when farther forced in the fire, or diluted, becomes green and tranfparent. It is found at Mufchlansberg in Zweybruck, or the Dutchy of *Deux Ponts* [a].

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[a] It is faid, that there is alfo found in the fulphur in Idria, a black cinnabar, that retains the colour in the fublimation, which feems to indicate an abundant phlogifton in the fulphur; but this requires, however, a further confirmation. *The Author.*

Dr. J. R. Forfter fays, *too boldly* on this matter, that the Author muft have been mifinformed, as *no fuch cinnabar* has *ever* been found; and adds, that a certain learned man thought he had likewife difcovered fome, near the copper ores at Lauterberg; but that it proved to be a red copper calx, which is ftill found there fometimes. *The Editor.*

SECT.

SECT. 295. (Additional.)

Quickfilver, mineralized by the marine and vitriolic acids.

Mineralogy owes the difcovery of this ore to Mr. Woulfe, who publifhed the account of it in the Phil. Tranf. of London, for the year 1776. p. 618, and following.

It was found in the Dutchy of Deux Ponts, at the mine diftinguifhed by the name of *Obermofchal.*

It had a *fpar-like* appearance. This ore is either *Bright* and *white*, or *yellow* or *black*.

It was mixed with cinnabar in a ftony matrix: and being well mixed with ⅓ of its weight of vegetable alkali, afforded cubic and octagonal cryftals, that is, *falt* of Sylvius, and *vitriolated tartar*.

The marine falt of this mercury is in the ftate of fublimate corrofive. The Editor from Kirwan, p. 309.

SECT.

SECT. 296. (220.)

Observations on Quickfilver (*a*).

The divifibility of quickfilver in the cold might occafion fome doubt, whether it really deferves

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[*a*] 1. The Noble Author fpeaks in the beginning of this Section, about the great *divifibility* (or rather *fluidity*) of Mercury in the common temperature of our climates; becaufe it was not known in his time, that this metal becomes *folid* and *malleable*, when expofed to the cold, indicated by the 40 degrees below *nought* in the fcales of the two thermometers of *Fahrenheit*, and of *Celfius*, as has been already mentioned in Note [*a*] to Sect. 286. It has alfo been fhewn, in the fame Note, why Mercury, far from being reckoned as one of the femi-metals, deferves rather to be ranked among the *perfect metals*, on account of its effential properties, which were either unknown formerly, or not attended to.

2. But this metal poffeffes moreover fome other fingular qualities, and is applied to various ufeful purpofes, as well philofophical as œconomical, part of which requires at leaft to be mentioned in this and in the next Note.

3. A notable property of quickfilver is, that of its being almoft regularly *expanded* or *contracted*, in its bulk, according to the greater or lefs quantity of heat to which it is expofed, as Mr. De Luc and other philofophers have fatisfactorily proved. It is on this account, as well as on that of its poffeffing a permanent form in all the common variations of the atmofphere, that mercury is the fitteft of all known fubftances in nature, to indicate with nicety the degrees of *heat* and *cold*, at any time or place whatever, independently of any reference to our fenfations, which are continually varying.

4. The relative quantity of this increafe or variation of mercury in its bulk, has been afcertained by Sir G. Shuckburg, in the Phil. Tranf. for 1777, p. 566. to be $\frac{10}{63,87}$ (= $\frac{1}{6,387}$; though, by error of the prefs, it is there marked $\frac{10}{637}$), from the

deferves to be called a metal, if it had not a right

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the *freezing point* of ice (or from its *melting*, which is a more precife *point*) to that in which *water boils*. To this quantity, however, muft be added $\frac{1}{400}$, on account of the expanfion of the tube in which the experiments were made; fo that the whole increafe of the bulk of mercury, by the variation of thefe two temperatures, amounts to $= \frac{1}{54,479} \left(\frac{63,07+400}{63,07 \times 400} = \frac{463,07}{25228} \right)$ of its former bulk.

5. This quantity, however, being too fmall to be eafily perceived, rendered it neceffary to make ufe of a proper contrivance to form that very ufeful inftrument, called the *Thermometer*. This confifts in a hollow ball of glafs, blown at the end of a narrow tube of the fame fubftance, whofe bore muft be very fmall and very even in its whole length. This being well filled with pure mercury, boiled, and hermetically fealed, without leaving any air in the infide, is expofed to the heat of boiling water, when the barometer ftands at 30 inches, the mean of its variations in our climates. The point anfwering to the upper furface of the inclofed mercury, is marked with a filk thread round the tube, and afterwards marked therein with a file; a fimilar mark being taken alfo when the inftrument is immerfed in thawing ice. The interval between thefe two marks is tranfpofed upon a brafs fcale annexed to the tube.

6. This fpace, or interval, is divided into 180 equal parts, or *degrees*, according to the fcale of Fahrenheit; or into 100 *degrees*, according to that of Celfius, ufed in Sweden: or into 80 *degrees*, according to that of Reaumur, ufed by the French. In the firft Scale the number 212 is put on the mark of *boiling water*; 32 on the *freezing point*; and the 0° on the 32 divifion below it. This is the moft convenient of the three thermometrical fcales, fince all variations of heat, in common obfervations, are diftinctly and fimply announced; and are fmall enough to render the ufe of fractions unneceffary; but thofe of *Reaumur* and *Celfius*, each of the firft being equal to 2,25° of *Fahrenheit*, and each of *Celfius* to 1,8 of the fame, require often to be fubdivided, and to be diftinguifhed by the words *above* or *below nought*, to be underftood without miftake. Thus, for inftance, 25 *degrees* of the Swedifh thermometer,

right to it from the earliest times, being then reckoned

meter, *above* or *below* $=25\times1{,}8\pm32=77$; or to 13 degrees of *Fahrenheit's* scale; and the same number of *degrees* of Reaumur's scale, are 25×2, $25\pm32=88\frac{1}{4}$, or to $24\frac{1}{4}$ of the same scale of *Fahrenheit*.

7. It was affirmed, in the beginning of this Note, that the expansions of the bulk of quicksilver by heat, are nearly (for they are *not strictly so*) in a regular arithmetical progression, according to the quantity of heat it is exposed to; and such seems to be the case, according to the Table published by the same Mr. de Luc, at p. 309, of his first volume on the *Modifications of the Atmosphere*. The following extract of this table shews these variations: and the first and second differences are added, in order to render these irregularities more sensible. They are such as can hardly be conceived from the nature of any substance, without the influence of extraneous and accidental causes, which may have escaped the attention of the observer; neither have they been found exactly true by Dr. Crawford. Mr. de Luc supposes the whole heat from the *melting ice* to that of *boiling water*, to be divided into 80 parts, by the fractional subdivisions of which he expresses the absolute quantities of heat, answering to each 5 or 10 degrees of Reaumur's thermometer ($=22{,}5$ of Fahrenheit's scale); so that the whole sum of these fractious amounts exactly to the assumed number 80; they are as follows:

Reaumur's Thermometer.	Fahrenheit's Thermometer.	Quantities of heat.	First differences.	Second differences.
Degr. 80	212			
70	189,5	9,44		
			,16	
60	167	9,60		+,06
			,10	
50	144,5	9,70		−,06
			,16	
40	122	9,86		−,06
			,22	
30	99,5	10,08		+,10
			,12	
20	77	10,20		−,06
			,18	
10	54,5	10,38		−,18
			,36	
0	32	10,74		

8. Our Author observes (Sect. 286. [*b*] p. 578.) that, although mercury is fluid, it is by no means *wet*; unless some water be intermixed in its substance. This last is a fact I have chanced

reckoned among the metals, when even they were

chanced to see more than once, by the watery vapour that arose from boiling quicksilver, previously to fill therewith some barometers. But chemists, less accurate in their words, express sometimes the adhesion of this metal to silver and gold, saying, that it *wets them*, on account of the external appearance arising from the strong attraction it has to both.

9. Though mercury does not act on earths; it unites and amalgamates with the greatest part of metals. This is a kind of solution which makes no effervescence, because no fixed air arises from these processes; and if any loss of phlogiston happens in the conflict, it is neither very considerable, nor with such a rapidity, as to render it self-known to our senses, as the Chemists of Dijon remark, Vol. III. p. 425.

10. The following articles relating to these amalgamations of mercury with other metals, are extracted from the same third volume of the Chemistry of Dijon, where the experiments of Mr. Sage of Paris are frequently quoted; and there is not the least doubt, but they have been repeated and well ascertained by the same Academicians.

11. The amalgam of gold and mercury, crystallises into quadrangular pyramids. Six ounces of mercury are retained by one of gold in this crystallization; but that with silver contains one-fourth more of quicksilver.

12. The strong mutual attraction between mercury and gold or silver, is the ground of the method of separating these metals, when they are native, from the earthy substances, that are naturally found mixed with in the mines; the smallest metallic particles forming an amalgam with it. Part of the mercury is strained off, and the remainder is afterwards dissipated by the heat of proper furnaces built for that purpose.

13. This amalgam serves also to cover pieces of copper and silver, with a golden surface, so that they appear as if intirely made of solid gold.

The pieces being well cleaned, are dipped in a feeble *aqua fortis*; afterwards in a nitrous solution of quicksilver, which covers their surface with a kind of silvering; and finally, the amalgam of gold is very equally spread over them: this being done,

done, the piece is exposed to a proper heat to volatilize the mercury, which leaves the gold strongly adhering to the metal, &c.

14. The amalgam with silver is also susceptible of crystallization. It assumes a dendritical form: and every ounce of silver retains 8 of mercury. It is with this amalgam that is produced, by means of *nitrous acid*, well freed from the vitriolic by the *nitrous solution of silver*, that curious apparent vegetation, called *Arbor Dianæ*, or *Arbor Philosophorum*. The following is the shortest process.

Dissolve 4 *gross* (=228 *grains*=4 × 72) of silver, and 2 (=2 × 72 *gr.*) of quicksilver in *pure nitrous acid*; add to the solution, when made, 5 *ounces* (=5 × 576 *gr.*) of distilled water: put this solution into a spherical vessel of white glass, at the bottom of which must already be put 6 *gross* (6 × 72 *gr.*) of an amalgam of silver, of the consistence of butter: let the vessel be kept in a quiet place, free from any shaking or external agitation; and, at the end of some few hours, the figure of a bush, or tree of silver, will be formed within the water of the glass vessel. The metals contained in the solution, and in the amalgam, attract each other; and a number of small tetrahedral crystals are formed, which lay hold at one another's end, and form the appearance of a vegetation, as I have seen in various cabinets of Natural Curiosities.

15. Quicksilver is also employed in Chili and Peru, to extract the native silver from its ores, by amalgamation, as has just been related, of those of gold: the mercury is either separated by distillation in large retorts of iron; or else the most fluid part is pressed out, and the remainder is driven off by a distillation *per descensum*, putting it in a kind of metallic sieve over a vessel of water, to receive the mercury, which is driven down by the fire lighted in a vessel above the amalgam.

16. Copper amalgamates very difficultly with mercury, and only by mixing *blue vitriol* with mercury and water in an iron retort, over the fire. The acid attacks then the vessel, and the copper is precipitated in a metallic state, which, by stirring it hot with an iron spatula, unites to the mercury; but it shews no kind of crystallization.

17. Two ounces of melted lead being poured on a pound of mercury, produce a half fluid amalgam, which being decanted, gives some crystals like those of silver. One ounce of these crystals retain one and a half of mercury. This amalgam is

is advantageously employed to lute the glass vessels, in which specimens of Natural History are to be preserved in spirits of wine, as it has an admirable effect in preventing evaporation by the close stoppage it makes.

18. The amalgam of quicksilver with tin, is advantageously employed in making looking-glasses, or mirrors. The thin sheet of tin is laid down on a large flat table of stone: a proper quantity of mercury (in which some tin has been dissolved, to avoid its destroying the tin sheet) is rubbed over, with a lump of cloth like a flat bung, and the glass is carefully slided upon it from one end to the other, in such a manner, that the dirty crust of the quicksilver is driven off before it's edge: the glass is then loaded with weights all over; by inclining gradually the stone-table, the superfluous mercury is discharged; and in a few hours both cohere together.

19. The amalgam of tin is susceptible of crystallization, which is in the form of thin shining *lamellæ*, with polygonous cavities between one another. Two ounces of tin retain 6 of mercury in this crystallization.

Quicksilver produces no amalgam with *iron* (See Note [*d*], N° 3. to p. 580.), nor with *regulus of antimony*. The first is the best intermedium to revive mercury from cinnabar: and antimony is also employed sometimes for the same operation, though not with equal advantage. See the Note to p. 593.

20. The amalgam with bismuth may be performed by heat: it produces regular crystals of an octaedral form, and lamellated triangles and hexagons; they are black on the upper surface, and shining underneath; two ounces of bismuth retain double their weight of mercury in this crystallization.

21. When fused zinc is poured on mercury, a crackling noise is heard, that resembles what is produced by a hot body when thrown into boiling water. This amalgam crystallises very well into lamellated hexagonal figures, leaving cavities among themselves. One ounce of zinc retains two and a half of mercury in this crystallization.

22. Quicksilver does not amalgamate with *arsenic*, but by the force of heat, and this in a very small quantity; nor does it amalgamate with *cobalt* nor with *nickle*.

Mr. Machy observed, that on the act of amalgamation, some cold is produced. He covered the ball of a thermometer with tin-foil, and putting it on mercury, the thermometer fell some degrees. This phenomenon thoroughly agrees with the

new

new doctrine of Dr. Crawford on *Elementary Fire*; as a solid body requires a greater addition of heat to pass from the solid to the fluid state: so that the sensible heat of the thermometer must be diminished, to unite to the tin-foil, with which it was covered, in the moment of becoming fluid.

23. This metal always feels cold, when touched, in the common temperature of the atmosphere. Fourcroy says, that we are deceived in this case by our own sensations; for the thermometer being dipped in the same mercury, does not show any lower degree of cold. The great continuity of contact between the live skin and the numerous metallic particles, in an equal space, which are proportional to its great specific gravity, necessarily produces a stronger sensation of its own temperature, this being always much less than that of a living body; and of course the multiplicity of these points of contact being all applied at once to this organ of our sensation, must be more powerfully felt, than whenever we touch any other matter that is lighter in itself, or of a much less density.

24. On the contrary, it is generally observed, that quicksilver, when exposed to the same degree of *heat*, and in the same circumstances, with various other bodies, becomes sooner hot than any of them. The fundamental principle of this phænomenon consists in the *small quantity of specific fire*, or in the *less capacity*, with which mercury is naturally endowed for receiving *heat*. This is such, that, compared with the capacity of water for the same purpose, it is in the ratio of 0,033 to 100, as appears by the Table I have published of the *specific fire* of various bodies, in my *Essay on Elementary Fire*. This Table was grounded upon various important experiments and observations made by Mr. Kirwan, in consequence of the *New Theory on Fire*, discovered and published by Dr. Crawford. Hence it follows, that if equal quantities of *heat* be communicated to two equal quantities of *water* and *mercury*, this last will have a temperature *thirty times* greater than water; that is to say, in the inverse ratio of their respective capacities, or as 1 to 30 (=0,033 : 1,000): in the same manner as it must happen, when equal measures of corn, or of any fluid, are thrown into vessels, whose bottoms are as 30 to 1; for then the heights must necessarily be in their inverse ratio, *viz.* of 1 to 30, &c.

 25. Mercury,

25. Mercury, when rubbed between the fingers, emits a slight particular odour, as Mr. Fourcroy asserts. I have attempted this experiment many times, but without success: perhaps on account of my imperfection, in the organ of this sensation.

The same Author asserts, that when mercury is pure, if agitated, it is observed to shine with a very sensible phosphoric light, particularly in hot seasons. This phænomenon has certainly been observed in the mercury of the barometer, by several philosophers.; but I do not know whether it is generally so in other circumstances: even in the barometer it does not take place, unless the Torricellian vacuum be not perfectly made in the space at the top of the tube. Phials of glass are made on this principle, containing some quicksilver, and hermetically sealed, which, on being shaken in the dark, produce light enough to see the hour on the dial of a watch. This luminous appearance is properly of the electric kind, and proceeds from the rubbing of the mercury against the sides of the glass, in a very rarified medium. But if a *perfect vacuum* be produced, by nicely boiling the quicksilver within the glass, there will not be any electric illumination. This coincides with that curious phænomenon, discovered by Mr. Walsh, and repeated by Mr. Morgan, as described in the Philosophical Transactions for 1786, p, 290. *viz.* that a perfect vacuum, or a space quite void of any substance, is absolutely impervious to the electric matter.

26. Quicksilver does not appear to dissolve in water: but Fourcroy remarks, that Physicians are in the practice of suspending a bag full of it in vermifuge ptisans, during their ebullition; and that experience has evinced the good effects of this practice. Lemery asserts, that there is not any loss of the weight of the mercury in this process; if so, there may issue from this metal some *effluvium*, which is mingled with the water, though so volatile and subtle, as not to diminish, in a sensible manner, its weight. Others, however, assert, that the mercury loses weight in this circumstance.

27. Lastly, mercury has not any taste perceptible by the nerves of our palate; but it, however, produces very remarkable effects on the stomach and intestines of animals, as well as on the surface of the skin. Insects and worms are infinitely more

more sensible than other animals of this effect: mercury kills them; and physicians employ it not only as a very excellent vermifuge, but as one of the most powerful remedies of the *Materia Medica* for many dreadful disorders, besides those of the venereal kind, for which it is undoubtedly the most singular and effective specific. But they are obliged to disguise it, almost continually, under various forms and denominations, in compliance with the absurd prejudices of the lower and illiberal part of mankind.

28. Even the most virulent product of mercury, known by the name of *Sublimate Corrosive*, already mentioned by the Author, p. 584. which is the most violent poison, is often taken internally in very minute doses, under the direction of skilful physicians, and produces the most happy effects in a great variety of cases, even of the most desperate kind. This is a fact which I have experienced myself, in a dreadful scorbutic complaint I suffered for above four years, with restless and violent pains of the eyes and head. None of the most able physicians in London and Paris I consulted, afforded me any effectual relief, till I had the good fortune to consult Mr. Sacré, surgeon oculist at Antwerp. His prescription consisted of three grains of *sublimate* dissolved in a pint of *common proof spirit*, called of *wine*, though it is, and ought to be, of corn (*frumenti*), or malt spirit; the dose consisted in taking every morning two spoonfuls of it, in a pint of new milk. In less than two weeks, I began to feel relief; and in three months time, I was completely cured. The first methodical practice of this remedy, was communicated to the famous Van Swieten, first Physician to the Emperor's Court, by my late worthy and very much regretted friend Dr. A. R. Sanches, then Archiater, or Chief Physician to the Court of Petersburg, as it appears by the last volume of the Commentaries of the same Van Swieten, p. 550. of the Leyden edition, in 4to, 1772. This volume was published after the Author's death; but he had enjoyed, during his life, the glory of being the author of this wonderful remedy, which continues to bear his name among the ignorant and inaccurate physicians of our times. *The Editor.*

were named after the metals, the number of both being thought equal (*b*).

[*b*] 1. The great *specific gravity* of quickfilver, being in fact the neareft to that of *gold*, and greater than that of any other metal, *platina* only excepted, fufficiently fhews, that this metal could not be ranged with propriety among the femi-metals. This gravity is, however, very differently appreciated by various Authors. Bergman, in his *Sciagraphia*, ftates it to be =14,110; and Muffchenbroek afferts, that fuch was the *fpecific gravity* of the quickfilver that had been fublimed 511 times. This, in all probability, was the fame of which Boerhaave fpeaks in his firft Differtation *de Mercurio*, p. 134. printed at the end of the fecond volume of his *Elementa Chemiæ*, Leyden, 1732. But fome other authors, among whom is Mr. Fourcroy, reckon this fpecific gravity to be no more than 13,000. Modern experiments fhow, however, that it generally lays between both, *viz.* about 13,600, or 13.500. This, I am informed, was the mean *fpecific gravity*, found by the late Lord Cavendifh, after the repeated and nice tryals he made upon 50 different fpecimens of quickfilver, on which he employed all his induftry and attention, to determine this point.

2. The hydroftatical experiments I lately undertook of this kind, upon 10 different fpecimens of mercury, two of which were revived from *native* and *artificial* cinnabar, by the operator of Mr. Kirwan, confirmed me in the fame opinion. The temperature of the atmofphere was nearly the mean, *viz.* at the 50th *degree* of Fahrenheit's thermometer; and the fcales employed in thefe operations were fo nice, that they turned with $\frac{1}{100}$ of a grain, when loaded with 4 pounds weight.

The method employed, in afcertaining thefe *fpecific gravities*, is the eafieft of all, and I thought it new, till I afterwards found it had been mentioned by Meffieurs Luyart, on their Treatife of the *Analyfis of Wolfram*. It is as follows:

3. A phial of white glafs, with a ground ftopple, was counterbalanced with lead, or other matter, in a nice pair of fcales. The fubftance to be tried, was introduced into the phial, and weighed together (fuppofe = *a*). The remaining

fpace

The opinion, which has a long time prevailed, that the quickfilver is a neceffary ingredient, and conftituent part in all metals, is not fo

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fpace of the phial being then filled with diftilled water, it was again weighed (fuppofe $=b$).

N. B. Particular care was taken, that no bubble of air remained in the infide. For this purpofe a very fmall grove was made, with a file, on the fide of the ground ftopple: this was introduced fideways, without admitting any air, leaving room to the fuperfluous water to rufh out. Laftly, the phial was emptied, and cleaned; and, being filled with the fame kind of water, was alfo weighed (fuppofe $=c$).

It is evident, that $b-a=d$ the quantity of water in the fecond operation: $c-d=e$ the water equal to the bulk of the fubftance; and that $\frac{a}{e}$ is the real *fpecific gravity* fought for.

4. The greateft fpecific gravity I found among thefe 10 fpecimens of mercury, was $=13{,}620$; and the fmalleft was $=13{,}450$. The *heavieft*, was neither of the two that had been diftilled from cinnabar; but a common quickfilver I had bought at Apothecaries Hall, in London; and the *lighteft* was taken from a barometer of the beft and dearer kind, made by one of our moft reputed inftrument-makers in England.

5. Various may be the caufes, which produce the great differences, that are obferved fometimes in the fpecific gravity of mercury. The moft obvious feems to be its mixture, or amalgamation with other metals. Certainly, when united to *gold*, its gravity muft of courfe be fpecifically augmented; on the contrary it muft be leffened, when amalgamated with any other metal, *platina* only excepted: and the fame muft be the event, whenever water, or moifture, is found mixed with mercury (N° 9. of this fame note to p. 615.); for in fuch a cafe it will be found heavier after evaporation. A fimple boiling of the quickfilver, for fome time over the fire, in an open veffel, will compleatly free it from this mixture; and no careful maker of experiments fhould ever neglect this preparation, before he undertakes to employ mercury in any procefs, or purpofe of the philofophical kind.

so generally received now as heretofore; since those processes, which have been advanced as proofs of it, and which have however but seldom

6. I have hinted already, upon good authority (Note *a*. N°. 2. to Sect. 286.) that mercury becomes not only purer, but *heavier*, after it has undergone very numerous sublimations.

The assertion of Boerhaave, in his dissertation already quoted (N°. 1. of this note), where he says to have examined the *specific gravity* of the mercury distilled 511 times, *per instrumenta irreprehensa et prudentissima solicitudine*, commanded my belief: but *quandoque bonus dormitat Homerus*; as I found, since the last sheet was printed, that the same respectable philosopher has exposed his doubts on the exactness of that operation, in a second Memoir, he sent, three years after the former, to the same Royal Society of London, which was inserted in the *Philos. Transactions* for 1736, p. 374; where he candidly acknowledges, that having continued to distill that quicksilver till 877 times, its specific gravity, shown by the nice hydrostatic balance of the ingenious Mr. 'sGravesande, appeared to be no more than 13,500, to that of distilled water.

7. Boerhaave died two years after (on the 23d of September 1738); and left his papers to his two nephews, Herman (who died the 7th of October 1753), and Kaw (deceased 5 years after, *viz.* the 6th of July 1758): after their deaths, these manuscripts fell into the hands of Charles Frederick Kruse, Physician to the Emperor of Russia. This gentleman published a short extract from Boerhaave's Diary, in the 9th vol. of the *Novi commentarii* of the Imp. Acad. of Petersburg, p. 390. The following are the resultts of this printed extract, which the reader may perhaps be pleased to find in this place.

The specific gravity of the purest gold, to distilled water is	19,024
That of mercury, distilled once in a glass retort	13,570
Distilled 1009 times . . .	13,590

dom been repeated, do by no means ſucceed, at leaſt not in all places.

It is rather ſuppoſed, that by the mercurial earth the ancients muſt have underſtood an earth,

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Diſtilled once from its amalgam with gold	13,550
Diſtilled 750 times from the ſame amalgam	13,520
Diſtilled 877 times from the ſame .	13,500
Diſtilled once from its amalgam with ſilver	13,550
Diſtilled 217 times, from the ſame amalgam, with ſilver . . .	13,500

8. It is evident, therefore, by theſe facts, that mercury does not acquire any additional increaſe to its *ſpecific gravity*, by the mere repetition of its ſimple diſtillations, nor by its amalgamations with gold or ſilver, provided it be afterwards properly ſeparated by fire.

9. In the ſame manner, when water, or moiſture, is found mixed, with mercury, as has been mentioned, N° 5. of this Note, if the moiſture comes to be evaporated, the mercury will remain heavier than before. This proceſs is very eaſily performed, it only requiring the mercury to be boiled for 20 or 30 minutes, in an open veſſel over the fire; as was already mentioned in the ſame place.

10. There remains ſtill another cauſe, from which ſome varieties may ariſe in aſcertaining the ſpecific gravity of quickſilver, as well as of other ſubſtances. This is the difference of the temperature of the atmoſphere at the time of making the operation. This has been a very material circumſtance, which was forgotten or unattended to, by almoſt all the authors, who have laboured hard to form large tables of the *ſpecific gravities* of numerous ſubſtances. Unhappily! for want of this eſſential circumſtance, their labours cannot produce any good effect; and, if not intirely uſeleſs, they cannot afford a proper ſatisfaction in the nice inquiries that depend on this kind of knowledge. The celebrated Chriſtian Wolfius, in his *Elements of Hydroſtatics*, Vol. II. p. 263, gives an abſtract of Eiſenchmid's table of *ſpecific gravities*, where it is aſſerted, that a cubic inch of mercury weighs, in ſummer, 7 *oz.*

which may, by addition of phogiston, be reduced in the fire to a metallic ftate; and this appears to be fo much the more reafonable, as

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1 grof. 66 gr.; but in the winter it weighs 20 gr. more; *viz.* 7 oz. 2 gr. of. 14 gr. This, however, leaves the whole nearly in the fame uncertainty; fince the *mean temperature* between fummer and winter is widely different in various climates, and in various local fituations; nor is it often the fame in every year at each place. So that, unlefs every time, that the *fpecific gravity* of mercury, or of any other fubftance, is taken, the degree of fome known and comparable thermometer, fuch as thofe of *Fahrenheit*, *Celfius*, or *Reaumur*, be declared, to afcertain the real temperature in which the operation was performed; there cannot be a poffibility of forming an adequate idea of the refults.

11. Before I difmifs the fubject, I muft beg leave to give a fpecimen, or two, of the enormous blunders committed by various philofophers and numerous pretenders, who have been extremely bufy in our times, to determine the heights of mountains, and the relative pofition of places above the level of the fea; by means of barometrical obfervations, without paying any particular attention to the *fpecific gravity* of the mercury, with which their barometers were made. If the two barometers were both at 30 inches high, and equally circumftanced in every other refpect, excepting only their *Specific gravity* of the quickfilver; fo that one be filled with the firft kind I have tried, *viz.* whofe fpecific gravity was = 13,62 and the other = 13,45.

In this cafe, and in all probability many of this kind have often occurred, the error muft have been no lefs than 327 feet; becaufe the heights of the mercurial columns in each barometer muft be in the inverfe ratio of their fpecific gravities: *viz.* 13,45 : 13,62 :: 30 : 30,379.

Now the logarithm of 30 = 4771.21
ditto of 30,379 = 4825.73

the difference is = 54.52

which difference fhows, that there are 54.52 *fathoms* between one place and another, or 327, *feet*; though in reality both places are on the fame level.

12. But

the quickfilver does not attract the metals when in the form of calces.

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12. But if the fpecific gravity of the mercury, in the two barometers, were as the two above mentioned by Bergman and Fourcroy; viz. one of 14,110, and the other of 13,000, which may happen to be the cafe, as the heavieft is commonly reputed the pureft mercury; on this fuppofition the error muft have amounted to 35,576 toifes, or above 2134, feet and a half; becaufe 13,000 : 14,110 :: 30 : 32,561
Now the logarithm of 30=4771,21
and that of 32,561=5126,97

the difference is=355,76; which fhows that the error fhould amount to fo many *fathoms*; or 2134,5 *feet*. *The Editor*.

ORDER

ORDER THE SECOND.

Imperfect, or Base Metals.

SECT. 297. (180.)

Tin, *Stannum*, *Jupiter*, Lat. *Zinn*, Germ. *Etain*, Fr.

Its Properties.

Tin is distinguished from the other metals by its following characters and qualities. It is

a. Of a white colour, which verges more to the blue than that of silver.

b. It is the most fusible of all metals [*a*]; and, The

[*a*] Tin melts in the fire before it grows red hot, and much easier than any metal, except quicksilver, *viz.* at the 415 *degree* of Fahrenheit's thermometer according to *Bergman.* Dr. Lewis says, that this degree is the 430; but, according to Nicholson, the 410 degree is a sufficient heat to produce the same effect. It would be an acceptable present to curious Metallurgists, if some nice experimenter should undertake to enlarge the table given in the Note to page 230; and ascertain the melting heat of all other metals, that are

c. The least ductile; that is, it cannot be extended or hammered [*b*] out so much as the others.

d. In breaking or bending it makes a crackling noise [*c*].

It

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are not mentioned in that table; by means of Wedgwood's new thermometer, which may be easily purchased at the inventor's ware-house, in *Greek-Street* Soho-Square. When tin is heated till almost ready to melt, proves extremely brittle: large blocks of it are, in this state, beaten into pieces from a blow of a hammer. The purer sort, from the facility of its breaking into long shining pieces, is called *Grain Tin.* When melted, if nimbly agitated at the instant of its beginning to congeal, is reduced into small grains or powder. *The Editor.*

[*b*] Tin is so ductile as to be beaten into very thin leaves. But *ductility*, and *extensibility*, are two different properties, less connected with one another than is generally imagined. Iron and steel are drawn into exquisite fine wire, but cannot be beat into very thin leaves. Tin, on the other hand, is beat into fine leaves, and may be extended between rolers to a considerable surface. The tin sheet used in various arts, is commonly about $\frac{1}{700}$ part of an inch; but may be extended twice as much in its dimensions, without difficulty. Notwithstanding this extensibility, tin cannot be drawn into wire, on account of the weak cohesion of its particles. A tin wire, however, of one-tenth of an inch diameter, is able to support a weight of 49 $\frac{1}{2}$ pounds, according to Fourcroy. Gold and Silver possess both properties of ductility and extensibility, the most eminently of all metallic bodies; whilst lead, notwithstanding its flexibility and softness, cannot be made either into leaves or wire of any fineness. *Editor, chiefly from* Lewis.

[*c*] This crackling noise, which is commonly supposed to be an essential property of pure tin, most probably belongs only to such tin as contains arsenic; for those operations, by which this noxious semi-metal is separated from tin, deprive it of that noise.

Henckel

Henckel discovered a method of separating actual arsenic from tin; namely, by slowly dissolving tin in 8 times its quantity of *aqua regia* made with sal-ammoniac, and setting the solution to evaporate in a gentle warmth. The arsenic begins to concrete whilst the liquor continues hot, and more plentifully on its growing cold, into white crystals. *Lewis.*

Marggraf has given a more particular account of this process in the Memoirs of Berlin for 1747. He observes, that the white sediment, which at first separates during the dissolution, is chiefly arsenical. That the tin of Malacca, though accounted one of the purest sorts, yield no less than one-fourth of its weight of arsenical crystals. That some sorts yield more: but that tin, extracted from any particular ore, which does not hold arsenic, affords none; so that this poisonous substance is but accidentally united to tin. Arsenic may be also separated from tin by means of mercury; for an amalgam of tin being long triturated with water, and the powder, which was washed off, committed to sublimation, a little mercury comes over, and bright arsenical flowers arise in the neck of the retort.

It was in consequence of Henckel and Marggraf's assertions, that the *Lieutenant General* of the Police at Paris gave it in commission to the College of Pharmacy in the year 1781, as Watson relates (Vol. IV. p. 153), to make all the necessary experiments for determining whether pure tin might, or not, be used for domestic purposes, without danger to health? In consequence of this commission, Messieurs Charland and Bayen published their researches, by which it appears, that neither the *East India*, nor the *purest* sort of *English* tin contained any arsenic, though the *English tin* usually met with in commerce, though not really English (See N° 3. of Note [*a*] Sect. 304.) did contain so small a portion of arsenic, that it not amounted at most to *on grain per ounce*, viz. $\frac{1}{576}$ of it's whole weight: and that such small portions of tin, as may be mixed with our food, from being prepared in tin vessels, can by no means become dangerous, or at all sensible in the animal œconomy. The large quantities of tin, which are sometimes given internally in medicine with perfect safety, and the constant use our ancestors made of tin vessels, before the introduction of china and other earthen wares, render all other proofs of the innocent nature of

e. It has a smell particular to itself, and which cannot be described [d].

f. In the fire it is easily calcined to white ashes, which are twenty-five per cent. heavier than the metal itself. During this operation, the phlogiston is seen to burn off, in form of small sparkles, among the ashes,, or calx [e].

g. This calx is very refractory; but may, however, with a very strong degree of heat, be brought to a glass of the colour of hard

of tin quite superfluous. *The Editor chiefly from* Lewis, Fourcroy, &c.

[d] When friction or heat is employed, the smell of tin becomes more remarkable.

It has also a disagreeable taste peculiar to itself, so very strong, that several physicians have ascribed to it a very perceptible action upon the animal œconomy; and have therefore recommended it in some diseases. *The Editor from* Fourcroy *and* Mongez.

[e] Tin by calcination contracts a brownish grey powder on its surface, which on raising the fire to a cherry red, swells, bursts, and discharges a small bright white flame of an arsenical smell. The metal, when just calcined, appears of a dusky greyish or ash colour; by a long continuance of the fire, becomes white, the more so in proportion as the tin was purer.

Though tin itself is so easily fused, its calx is extremely refractory. Even in the focus of a large burning lens, or of a concave mirror, it only softens a little, and forms crystalline filaments. With glass of bismuth, or with the simple, or the arsenicated glasses of lead, the most powerful fluxes known for refractory calces, it does not perfectly vitrify, forming only opake milky compounds. By this property it is fitted for making the basis of the imperfect glasses, called Enamels. *Editor from* Lewis.

rosin,

rosin, or *Colophony*. But this calx is easily mixed in glass compositions, and makes with them the *white enamel*.

h. It unites with all metals and semi-metals; but renders most of them very brittle, except lead, bismuth, and zink [*f*].

i. It amalgamates easily with quicksilver. *See* the Note n° 18 to *page* 608.

[*f*] Notwithstanding that tin of itself is so soft and so unsonorous, it surprizingly improves the sonorousness, and destroys the ductility, of some of the other metals, particularly gold, silver, copper, and brass. Bell metal, the most sonorous of all metallic bodies, is a composition of copper and tin. The minutest portion, even the vapour of tin, renders many ounces, and even pounds of gold or silver, so brittle, as to fall into pieces under the hammer. The least particle of tin, falling on the stones or luting of a furnace, will make all the gold and silver melted in it, hard and brittle. On this account Tin is called, by metallurgists, the *Diabolus Metallorum*. Thus far is the assertion of Neumann, p. 125 and 126. Vol. I. of his *Chemical Works*. See also note [*i*] to p. 519.

But it appears, by the experiments of Mr. Alchorne, Assay Master of the London-Mint, that gold, with $\frac{1}{96}$, and even with $\frac{1}{48}$ of tin, does not become brittle. *See* Phil. Transact. *for* 1784, *p.* 464.

Tin, the most fusible, and iron, the most refractory of all the metals, unite easily with one another, and seem to have a great affinity. Iron dissolves by melted tin, in a heat far less than that in which iron by itself melts. The compound is white and brittle. Iron, added to a mixture of lead and tin in fusion, takes up the tin, leaving the lead at the bottom; and, in like manner, if lead, tin, and silver, are melted together, the addition of iron will absorb all the tin, and the tin only. Hence we are furnished with a method of purifying silver from tin, and consequently of preventing the inconveniencies, which this metal occasions in the refining of silver by cupellation with lead. *The Editor, chiefly from* Neumann *and* Lewis.

k. It

k. It dissolves in aqua regia, the spirit of sea-salt, and the vitriolic acid; but it is only corroded into a white powder by the spirit of nitre [*g*].

[*g*] Nitrous acid acts very powerfully on tin. To obtain a perfect solution, the metal must be added a very little at a time, and all heat avoided. If much tin be put at once, the corrosion takes place with great rapidity and heat; and the metal is deprived so much of its phlogiston, that it falls to the bottom in the form of a white calx, insoluble in acids, and of difficult reduction: Macquer acknowledges, that he could never succeed in the attempt. This calx is advantageously employed in making the white enamel. According to Bayen and Charlard, quoted by Fourcroy, from the solution of tin with nitrous acid to saturation (so that the acid be thick and incapable of acting on a new addition of the metal) by washing this mass in a great quantity of distilled water, and evaporating this ley to dryness, a salt *stanno-nitrosus* is got, which detonates alone in a well-heated pot: and burns with a thick white flame, like that of phosphorus. Aqua Regia, made of two parts of nitrous, and one of marine acid, combines with tin; and makes a strong effervescence. The metal must be put in the solvent, only little by little; or else a great part will be calcined. The aqua regia may in that manner be impregnated with half its weight of tin. This solution of tin exalts the tincture of *cochineal*, of *gum-lac*, &c. turning the colour to that of strong fire-red: which is employed by dyers to give the scarlet colour to cloth. It serves also to precipitate the gold from its solution, into a fine purple coloured calx, called *the Powder of Cassius*, its inventor, which serves to give that colour to glass and enamel (See p. 530).

The muriatic or marine acid dissolves tin by means of heat: if it be granulated, and put into a matrass over the fire, a small effervescence is produced; when saturated, above half the weight of the tin is found dissolved, and fine crystals may be produced from the solution, by the usual process in similar cases.

The vegetable acid, ſoaps, and pure alcaline ſalts, alſo corrode this metal by degrees.

Of all the acids, the marine acid has the greater affinity with tin; but does not diſſolve it without heat. It forſakes ſilver, mercury, and antimony, to unite with tin. When thus combined, it volatiſes a conſiderable part of the metal: and a ſtrong ſmoking ſpirit comes over, which, if diluted with water, grows milky, and depoſits the tin. This ſpirit is known by the name of *Fuming Liquor of Libavius*, and is a pure marine acid *charged*, but not *ſaturated* with tin.

An amalgam of four parts of *tin*, with five of *mercury*, being well triturated in a glaſs mortar, with an equal weight of corroſive ſublimate, the whole is put in a glaſs-retort, and expoſed to a reverbatory furnace, having luted to it a large receiver, with a little hole on the top to give vent, when neceſſary, to the elaſtic vapours. The diſtillation muſt be begun with a gentle heat. At firſt a colourleſs liquor paſſes over, and a white thick vapour riſes, which emits white and copious fumes. This liquor, contained in a phial, diſcovers no ſigns of vapour; a certain quantity, however, is diſengaged, which depoſits the calx of tin in needle-like cryſtals upon the upper part of the phial; and a ſmall quantity of calx is alſo precipitated at the bottom, in the form of irregular leaves. It has a very penetrating ſmell, which excites coughing. This gas of the liquor has but a ſmall degree of elaſticity. The reſiduum, after diſtillation, preſents an amalgam of mercury and tin; and above it a kind of butter of tin, or *ſtannum corneum*, which may be volatiliſed by the force of heat.

Vitriolic acid, according to Neumann, requires to be highly concentrated, and aſſiſted by a boiling heat, in order to diſſolve tin. The inflammable principle of the metal, extricated during the ſolution, unites with a part of the acid into a true ſulphur, which ſublimes, in its proper form, into the neck of the retort; and a vitriolic acid air eſcapes during the ſolution. *See Note* [a] *to p.* 491. *concerning the formation of* Sulphur. *The Editor chiefly from* Macquer and Fourcroy.

l. Its

l. Its ſpecific gravity is to water as 7400 to 1000, or as 7321 to 1000 [*b*].

m. Diſſolved in aqua regia, which for this purpoſe ought to conſiſt of equal parts of the ſpirit of nitre and ſea-ſalt, it heightens the colour of the cochineal, and makes it deeper; for otherwiſe that dye would incline to violet.

[*b*] The lighteſt tin is the pureſt. According to Bergman its ſpecific gravity is =7264. According to Cotes, Ferguſon, and Emerſon, it is =7320. According to Boerhaave=7321; according to Muſſchenbroek and Wallerius=7471; and, according to Martin it is=7550. But Watſon ſays, that none of the authors he quotes, in eſtimating the ſpecific gravity of tin, had uſed the pureſt ſort, but rather a mixture of it with lead: and gives the following table of the weights of various mixtures of tin with lead, by which the *ſpecific gravities* are at the ſame time known.

One ſolid Cubic foot of	*weighs*	*ounces* Avoirdupois.
Pure lead	- - -	11270
Pure tin	- - -	7170
Tin 32 parts, lead 1	- -	7321
Tin 16, lead 1	- - -	7438
Tin 10, lead 1	- - -	7492
Tin 8, lead 1	- - -	7560
Tin 5, lead 1	- - -	7645
Tin 3, lead 1	- - -	7940
Tin 2, lead 1	- - -	8160
Tin 1, lead 1	- - -	8817

SECT. 298. (Additional.)

Native Tin.

The existence of native tin has long been questioned; but it has undoubtedly been found some years ago in *Cornwall*, as Mr. Kirwan remarks [a].

1. Malleable tin, in a granular form, and also in a foliaceous shape, issuing out of a white hard matter like quartz; but which, after

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[a] Our Author said, in his sect. 181, that *tin is not found in the earth in any other state than that of calx, crystallized*, &c. but these words were suppressed in the present edition; because the contrary has been proved by facts, although not known in his own time. Likewise Professor Bergman, in his *Sciagraphia*, sect. 208, published in 1782, says, that some doubts were entertained of the existence of native tin, perhaps not without reason. But this assertion seems rather inconsiderate, as it appears by his own *Theory of the Earth*, published in 1766 at Upsal, and quoted by Dr. J. R. Forster, that he (Mr. Bergman) received an account from Mr. Quist, by which he asserts that Mr. Rinman had seen a specimen of *native tin* in a soft stone, with crystallized quartz, and surrounded with a rind of *tin-zwitter*, or tin-stone. The same Dr. Foster quotes also, in confirmation of this assertion, the vol. XXVII. p. 231. of the *Swedish Transactions*, and the *Systema Naturæ* of Linnæus, vol. III. p. 236. of the 12th edition.

And finally, Wallerius says, that it has been found in the Duchy of *Deuxponts*, in *Cornwall*, and at Malacca in the East Indies. *The Editor.*

being

being properly aſſayed, proved to be arſenical cryſtals, a circumſtance that evinces its being native tin; ſince the arſenic could not remain in this form, if the tin had been melted. It appeared like a thick, jagged, or ſcolloped lace or edging; and was found near St. Auſtle in Cornwall [b].

2. In the form of cryſtalline metallic laminæ, or laminated cryſtals, riſing ſide by ſide out of an edging, which ſhone like melted tin; they were almoſt as thin as flakes or ſcales of talc, interſecting each other in various directions, with ſome cavities between them, within which appeared many ſpecks and granules of tin, that could be eaſily cut with a knife: this was alſo found in Cornwall [c].

3. In

[b] A ſpecimen of this ſort was found in 1765, and ſent by Mr. William Borlaſe, author of the *Natural Hiſtory of Cornwall*, to the Muſeum at Oxford, where it may be inſpected. It was enveloped by an outer cruſt, of about one-eighth of an inch thick, of a browniſh ſtraw-colour; the ſecond or inner coat was blacker, cloſer-grained, with ſome faint appearances of whitiſh ſpecks, about one-third of an inch thick. Phil. Tranſact. 1766. p. 36.

[c] The lump or product, of this, and the preceding ſpecimen, was very richly impregnated with tin; and though the beſt tin-ore, in general, will not melt without flux, nor do twenty pounds of block-tin uſually produce more than 14 pounds of the metallic regulus; yet, this tin melted without any flux; and 20 ounces of it produced 16 of good tin, *viz.* at the rate of 80 per hundred. See the Phil. Tranſact. vol. LVI. p. 37.

3. In a maſſy form, more than one inch thick in ſome places, and incloſed in a kind of quartzous ſtone: or rather in an hard cruſt of cryſtallized arſenic [d].

S E C T. 299. (181.)

Calciforme Ores of Tin [a].

1. In form of a calx, *Stannum calciforme.*
 A. Indurated, or vitrified, *Induratum.*

1. Mixed

This ſpecimen was preſented by the ſame Wm. Borlaſe, and depoſited in the Collection of Foſſils of the Royal Society of London, where I ſaw it many years ago; but it may be now found in the Britiſh Muſeum, where that collection was removed, by a kind of ſurprize, without the majority of the members being apprized before hand of any ſuch intention.

According to E. M. Da Coſta, the tin of this ſpecimen is perfectly ductile and malleable, and bends between the teeth, giving the ſame cracking noiſe as tin does. It melts eaſily in an open fire; calcines in the fire, aud emits ſome ſmoke: being urged in a ſtrong fire, with borax, it detonates with ſmall phoſphoreſcent ſparks, as pure tin does: is corroded to a white calx in nitrous acid, and, by adding oil of tartar *per deliquium*, no precipitation was produced. *See the Phil. Tranſact.* already quoted. *The Editor.*

[d] This was a lump of tin-ore found in a ſtream work, near the Borough of *Granpont* in *Cornwall*, weighing near 12 pounds; and ſo well covered by its cruſt, that, but for its extraordinary weight, it might have paſſed unnoticed. The fragments ſtill in the poſſeſſion of Mr. Roſewarne in that place, prove by the granulated external ſurface, and ſhotten edge, to be native tin. *Phil. Tranſact.* for 1766, *page* 38.

[a] Theſe ores are remarkable for their great weight; their ſpecific gravity being from 5,955 to 6,750. *Kirwan.*

In

1. Mixed with a ſmall portion of the calx of arſenic, *Minera ſtanni vitrea arſenicalis.*

a. Solid tin-ore, without any determinate figure. Tin-ſtone.

It

In order to aſſay an ore of tin, Fourcroy directs to divide it into different pieces, and reduce them into a groſs powder; to ſeparate the earthy part by waſhing, and to roaſt the remainder in a covered earthen veſſel. In Germany they are roaſted in reverberating furnaces, to which an horizontal chimney is affixed to collect the ſulphur and arſenic that are found mixed in the ore; the roaſted ſubſtance is afterwards melted in the air-furnace, and run into moulds in order to form the pigs or blocks of tin for ſale.

To aſſay tin ores in the *liquid way*, has hitherto been thought impracticable; however, Mr. *Bergman* has contrived the following method, which is generally ſucceſsful. Let the tin ore, well ſeparated from its ſtrong matrix by waſhing, and reduced to the moſt ſubtle powder, be digeſted in concentrated oil of vitriol, in a ſtrong heat for ſeveral hours; to this, when cool, add a ſmall quantity of concentrated marine acid, and ſuffer it to ſtand for one or two hours; then add water, and when the ſolution is clear pour it off; and precipitate it by fixed mineral alkali. 131 grains of this precipitate waſhed and dried, are equivalent to 100 of tin in its reguline ſtate, if the precipitate conſiſts of pure tin; but if it contains copper or iron, it ſhould be calcined for one hour in a red heat, and then digeſted in nitrous acid, which will ſeparate the iron. *The Editor from* Kirwan.

Almoſt all the tin ores of Cornwall are in a calciform, and at the ſame time in an indurated glaſs-like ſtate. The *Zinnſtein*, or *Tinſtone* of the Germans, might ſerve as the general denomination of them; but only the irregular and compact ſpecies are called ſo. The cryſtallized tin-ſtones, on the contrary, are called *Zinngraupen*, if the cryſtals are diſtinct,

 and

It resembles a garnet of a blackish brown colour, but is much heavier; and has been considered at the English tin mines as a stone, containing

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and somewhat large; but *Zinnzwitter* are those in which the crystals are small and not so distinct, resembling small grains, scattered through a compact raw tin-stone, or a stone of any other kind.

These species of Cornish tin-ores differ from those of Bohemia and Saxony, by containing much less *iron*, and less arsenic; and this is the cause of the preference the English tin in general obtains, above any other tin, *viz.* on account of its purity.

The common matrix of tin in these mines is the *killas*, already described at p. 261: and the *growan*. This consists of *white clay*, mixed with *mica* and *quartz*, without any particular texture; which, when lamellar and hard, is called *Gneiss* by the Germans; and is nothing else but decayed *granite*, in which the *Feldspar* (Sect. 113.) has been broken down to clay.

The *Zinngraupen* from Cornwall is the most remarkable, though rare. It consists of quadrangular prisms, or double quadrangular pyramids joined by their bases, so that these crystals are octoedral; these are found at *Trevaunance* and *Soil-hole*, in the parish of St. Agnes. Similar prismatic crystals, but of as small a size as a hair, are found in tin-stone upon *Killas*, at Polgooth, one of the richest tin mines, which produces sometimes a clear profit from 1000 to 1200 pounds *per* month.

The *Stream-tin*, is collected in the valleys of the tin-mountains in Cornwall, and yields a considerable quantity of this metal. The soil is dug several feet deep, and washed by water going over it, till the heavier particles of the ore remain at the bottom. These are nothing else but the abrasions of the tin ores over the mountains, which are rolled down the declivities of the hills to lower grounds.

The stream-tin from Pensagillis is remarkable, on account of the native gold now and then met with in it; and found, containing no metal, until some years ago it began to be smelted to great advantage [*b*].

found, though very rarely, in pieces of the value of two or three pounds sterling. It principally consists of round, oval, and somewhat smooth pieces, from the size of a bean to that of a pea, and less, whose polished surfaces show a variety of reddish, grey, light-brown, and dark yellow colours.

The *wood-tin*-ore looks like hematites, and is found only in the Parishes of St. Columb, Roach, and St. Denis. This is without any crystallized form; and has a very inconsiderable quantity of iron with it.

Another wood like tin ore, described by Professor Brunnich, shows various fine fibres converging to different centres, like the radiated zeolyte; but is so compact and hard, as to strike fire with steel. Its specific gravity at the 45° of Fahrenheit, is 580, and even 645. It contains some arsenic and a considerable proportion of iron; and gives sometimes 63,5 *per cent.* of tin. It is very scarce, and found only in small bits. *The Editor from the Treatise of* M. H. Klaproth, *published when this sheet was going into press.*

[*b*] The *Tin-stone*, *Zinnstein* of the Germans, *Tenberg* of the Swedes, consists chiefly of stones and sands of different sorts, which contain calx of tin invisibly disseminated through them. Their specific gravity, when the proportion of tin is considerable, is very great. They may be of any colour: The *blue*, *grey*, *black*, or *brown*, are the commonest. They are vulgarly called *lode-stones*.

N. B. 1. The ore ealled *Weiss Zinngraupen* by the Germans, is that which was mentioned under the calcareous genus by the name of Tungsten. (See p. 46 and 47 of this edition;) but this ore contains no tin.

2. When any arsenic is found in tin, it proceeds from it's matrix; for tin itself is never found mineralized by it, but only mixed therewith, And under the same circumstances zinc is sometimes found in tin.

3. It is remarkable that tin has not as yet been found in any stones of the *calcareous* genus, except *fluors*; but in those of the *siliceous* or *argillaceous kind. The Editor from* Kirwan.

SECT. 300. (Additional).

Calciform Tin Ores cryſtallized [a].

The tin ſpar, or white tin ore, is generally of a whitiſh or grey colour; ſometimes it is *yellowiſh, ſemi-tranſparent*, and *cryſtallized*, either of a pyramidical form, or irregularly. It was formerly thought to contain arſenic, but Mr. Margraaf found it to be the pureſt of all tin-ores; though it is ſaid to contain ſometimes a mixture of calcareous earth. Its ſpecific gravity is = 6,007. *Kirwan.*

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[a] The Tin-ſpar reſembles a white calcareous ſpar; but its conſtituent parts are more compact, and its weight greater. Some writers, and even our author, have doubted whether it contained tin. It is found, though very ſeldom, at Shlakkenwalde in Bohemia; and contains tin, as I am credibly informed. But there is likewiſe a heavy mineral very like *tin-ſpar*, without any particle of this metal in it. *Brunnich.*

Tin ore reſembling quartz, I have ſeen in Mr. De l'Iſle's cabinet at Paris, Its colour is white, and it ſeems to be mineralized by the aerial acid. *Fabroni.*

SECT. 301. (Part of § 181.)

Tin Grains [a].

This ore like the garnets, is of a ſpherical polygonal figure; but ſeems more unctuous on its ſurface.

1. In large grains.
2. In ſmall grains*.

SECT. 302. (182.)

Calces of Tin, mixed with Metals.

1. Tin is found mixed with the calx of iron, as in the garnet. *See Sect.* 117 [b].

2. Tin

[a] The *opake*, *brown*, or *black tin-ore*, is alſo cryſtallized, and imbodied in a ſtrong matrix of quartz, fluor or mica; or mixed with white or yellow pyrites; or in ores of lead or zinc, cobalt, or iron. When theſe cryſtals are large, they are called by the Germans *Zinngraupen*, and when ſmall *Zinn-zwiter*. The *black* are reckoned the richeſt, and afford about 80 *per cent* of tin. They all contain a mixture of iron. *The Editor from* Kirwan.

[b] Bergman ſpeaks alſo of ores of tin in the ſtate of calx, contaminated by iron, in the *ſect.* 209 of his *Sciagraphia*:

And the *zinn-zwitter* of the Germans already mentioned in the Note to the laſt Section 299, p. 630; contains alſo ſome mixture of iron, as Kirwan aſſerts.

Wallerius

* *See the* Notes *to p.* 629 *and* 630.

2. Tin mixed with Manganese. *See* Sect. 117 *of the Author, which will be inserted among the* semi-metals.

3. Tin mineralized with sulphur and iron [c].

Wallerius asserts that the striated tin-ore from Siberia, which has the appearance of amianthus, called by the Swedish *Strælig Tenmalm*, and by the Germans *Strahlichtes Zinnerz*, is mineralized by arsenic and iron. But this mineralization of tin seems very doubtful, insomuch, that Kirwan positively asserts, that tin itself is never mineralized by arsenic. *See Note* [*b*] N° 2. p. 631. The Editor.

[*c*] The Noble Author had the mistaken, but plausible notion, that *plumbago*, or *black-lead*, was a compound of *sulphur*, *tin*, and *iron*. Indeed the shining appearance of the *aurum musivum*, to be mentioned in Sect. 303, which is a compound of tin and sulphur, was a very specious indication to adopt such a supposition; he had said, in the words that have been suppressed in the beginning of his Sect. 154 (*viz.* 231 of this Edition), *if such a mixture of* sulphur, iron, *and* tin, *be not rendered too volatile, it must be supposed that the great loss the* blacklead *sustains in the calcining heat, is occasioned from the* sulphur: *and that the* sulphur *consequently makes out the greatest part of the* black lead. But the true analyses of the *plumbago*, which have been repeatedly made since the Author's time, demonstrate, that black-lead has very different component parts, as was shewn in Section 231; and is also of a very different nature from Molybdena, which the author thought to be only a variety of plumbago, it being of a metallic nature, as will be said in it's proper place hereafter, among the semi-metals. *The Editor.*

SECT.

SECT. 303. (Additional.)

Aurum musivum.

Tin mineralized by sulphur was lately discovered by *Prof. Bergman*, among some minerals which he received from *Siberia* [a]. He observed two sorts of it analogous to the two artificial combinations of tin with sulphur.

1. One nearly of the colour of zinc, and of a fibrous texture, which contained about twenty *per. cent.* of sulphur, and the remainder tin.
2. The other inveloped the former like a crust; resembled *aurum musivum*; and contained about forty *per cent.* of sulphur, a small proportion of copper, and the remainder tin. *Mem Stock*, 1721, p. 328. *Quoted by Kirwan* [b].

At

[a] This ore was found at *Nerchinskoi* in Siberia. The part resembling *aurum musivum*, was the outside crust, and in the middle was a nodule of a white metallic appearance, similar to crude antimony, although it did not contain any. This was radiated from the center outwards; could be easily cut with the knife, after which the surface appeared of variegated colours; and being pounded, produced some black powder. Both these substances were contaminated by a small quantity of copper. *The Editor from* Bergman.

[b] This account of the new ore of tin, given by Bergman in the said Memoirs of Stockholm, has been translated into French, and inserted in the *Journal de Physique*

for

At *Huel Rock*, in St. Agnes in Cornwall, there has been found a metallic vein, 9 feet wide, at 20 yards beneath the surface. Mr. Rafpe was the firft who difcovered this to be a fulphurated tin-ore: it is very compact, of a bluifh-white colour, approaching to grey-fteel, and

for May 1783, pag. 367. It is directly afferted there, that the proportions of the component parts of this ore, *could not be afcertained*, on account of their minutenefs. From hence it is evident, that thofe proportions, mentioned by Bergman in the *Preface* to his Sciagraphia, where he fpeaks of the fame new ore of tin, amount to no more than to a fimple guefs, from the comparative dofes, he mentions in the faid memoir, for producing by art two fimilar fubftances; the firft by melting 20 *per centum* of fulphur with tin in a crucible, which produces a fhining mafs, like zinc, that has a radiated appearance when broken; but if the quantity of fulphur be double (*viz.* 40 *per centum*), and the fire is ftronger, a fhining yellow mafs is formed, which is compofed of very fmall and thin fcales, like the *aurum mufivum*, or *mofaicum*, as others call it.

The procefs given in the London Difpenfary, for making artificial *aurum mufivum*, confifts in melting 12 *ounces* of of tin, in a crucible, and adding, after it is fufed, 6 *ounces* of pure mercury. This brittle amalgam, after being cold, is pounded, and mixed with 6 *ounces* of fal ammoniac, and 7 *ounces* of flowers of fulphur. The whole is fublimed in a matrafs: and the *aurum mufivum* will be found in the fublimated matter, and fome little drofs. Mr. Woulfe fays, in the *vol.* LXI. of the Phil. Tranfact. p. 125, that 3 *ounces* of *mercury*, and as many of *fal ammoniacum*, is ftill a better proportion of the above ingredients; and that the *aurum mufivum* fo produced, amounts then to 17½ ounces, whilft that of the former dofes, gives only 16 ounces. This procefs requires a graduated fire in the beginning, which muft be increafed, and continued for the fpace of 5 or 6 hours. *The Editor.*

According

and fimilar to the colour of grey copper-ore: it is lamellar in its texture, and very brittle. It confifts of *fulphur*, *tin*, *copper*, and fome *iron*. Mr. Rafpe propofes to call it *Bell-metal-ore* [c].

SECT. 304. (183.)

Observations on Tin.

It has indeed been afferted by fome, that tin is found native in the earth; but, for my own part, like many others, I doubt much of it, having never feen a fingle fpecimen that could be called native tin [a].

It

[c] According to Mr. Klaproth's analyfis of this ore, 119 grains contain 30 of pure *fulphur*; 41 of *tin*; 43 of *copper*; 2 of *iron*; and 3 gr. of the *Stony matrix*. In another fpecimen of the fame fulphurated tin-ore from Cornwall, there were in the *hundred* 25 parts of *fulphur*, 34 of *tin*, 36 of *copper*, 3 of *iron*, and 2 of the *ftony matrix*.

[a] 1. The contrary to this opinion of our author, has been fully demonftrated in *Sect.* 298, *note* [a].

2. Tin, though fometimes unmixed in its ores, is often otherwife; they frequently contain both iron and copper. The fire, with which tin is melted, is fufficiently ftrong to fmelt alfo the other metals contained in the fame ores; and hence, without any fraudulent proceeding in the tin-fmelter, there may be a variety of other fubftances in its mafs. But this natural variety is far lefs than that which is fraudulently introduced; becaufe tin is above five times dearer than lead; and as a mixture, confifting of a large portion of tin with a fmall one of lead, cannot be eafily diftinguifhed from a mafs of pure tin, the temptation to adulterate it is great, and the fear of detection fmall.

3. In

It is, however, remarkable that tin is so scarce, and is not found in any considerable quantity

3. In *Cornwall* the tin, after being smelted from the ore, is poured into quadrangular moulds of stone, containing about 320 pounds weight of metal, and it is then called *block-tin*. The officers, appointed by the Duke of Cornwall, assay it, by taking a piece of one of the under corners of each block; and, if found pure, it is stamped with the seal of the Duchy. It is clear, that if the tin is mixed with lead, this by its superior weight sinks to the bottom, and will be liable to be discovered, when the under corner is employed in the trial. But this seal gives no security for the goodness of the tin sold abroad, since it is known, and Neumann asserts it (p. 131 of his first vol. in 8vo), that in Holland, every tin-founder has English stamps; and whatever his tin be, the inscription *block-tin* makes it pass for *English*. Watson.

4. Whenever the filings of tin, held over the flame of a candle, yield a smell resembling that of garlic; it contains an arsenical mixture: the most part of common tin is in this case; and some think that the crackling noise in bending, which is supposed to be an essential property of pure tin, belongs only to such as is arsenicated; for after those chemical operations, by which the arsenic is separated, the tin is deprived of that noise.

5. Tin melted with arsenic, falls in great part into a whitish calx; the part which remains uncalcined, proves very brittle, appears of a white colour, and shows a sparkling plated texture, greatly resembling zinc. The arsenic is very strongly retained by the tin, so as scarce to be totally dissipable by any degree of fire, though the mixture be urged for a length of time, with a very intense heat. The tin, after being recovered by fusion with inflammable fluxes, discovers, by its appearance, by its brittleness, and by its augmentation of weight, that it still holds a considerable portion of the arsenic. *Lewis*.

6. Tin exposed to a very violent heat, produces a whitish and brilliant flame; a white smoak rises; which condenses

into a whitish needle-form calx, which is called *Tin flowers.* Mongez.

7. Neumann observed, that on mixing iron and tin in the focus of a Tschirnhausen's burning-lens, if the tin was melted first, and the iron added, they united together very quietly; but when the iron was melted first, the addition of tin occasioned a crackling, and a sputtering of little globules, which burst with a considerable snap; and instead of fumes, there arose exceeding fine filaments, which stuck to the cloths, &c. like cobwebs.

8. This kind of detonation, produced by the union of tin with iron on a very violent fire, and the extreme eagerness with which it is attacked by nitrous acid, as mentioned, *note* [*g*] to Sect. 297. may well account for that curious deflagration described by Dr. Higgins in the vol. LXIII. p. 137 of the Phil. Transact. which I have repeated a great many times to some curious persons of my acquaintances. Several small pieces of cupreous nitre (a salt which results from the solution of plated copper in nitrous acid, after evaporation, or nearly so) being put in a piece of tin-foil, with a very few drops of water, and being quickly rolled or wrapped up, with the extremities bent up, and pinched together: 1. the salt deliquesces in the inside of the tin: 2. this last changes its colour: 3. a froth issues out at the ends of the coil: 4. then a considerable warmth is produced: 5. it emits nitrous fumes: 6. an intolerable heat follows: 7. and at last it bursts with an explosion and fire, fusing the tin-foil in several places. In this case, the acid being moistened, quits the copper, and acts at once on the large surface of the tin, with such an eagerness as to kindle its phlogiston into a blaze.

9. Macquer observed, that putting a good quantity of granulated tin in a matrass over the fire, the marine acid, which he poured upon it, immediately lost its own fumes; attacked the tin with a sensible but moderate effervescence, and dissolved it to saturation. The solution was as white and transparent as pure water, and dissolved above the half of its weight of tin. When kept for some time in a glass vessel, it crystallized during the cold weather, but became fluid in the summer. Crystals of tin may be formed by the ordinary method, which are of great use in the *calico-printing* processes. *The Editor.*

The

quantity or purity in any other places in Europe, than in England and Saxony [b].

It

[b] The largest quantities of tin are met with in England, particularly in the county of Cornwall. There is some also in Bohemia and Saxony, as well as in the East-Indies; but in other countries it is rare to find so much as to be worth the trouble and expence of extracting.

2. Britain is supposed to have received its name from its abounding with this metal. For tin being called *Bragmanack*, in the Syriac and Chaldaic languages, that is, the kingdom of Jupiter; from hence seem to have been deduced the words *Bratman*, *Britman*, and *Britania*. Newmann.

3. The uses of tin are very various. It is employed in a great number of arts. Its use, when united to mercury for making looking-glasses, has been already described in note N° 18. to Sect. 296. p. 608. Bishop Watson seems inclined to believe, on very good grounds, that the art of making looking-glasses, by applying to their back-surface a metallic covering of tin-plate imbibed by quicksilver, is not a very modern invention; and quotes the great Pliny, who asserts, that the Sidonians had invented something of this kind. *See* vol. IV. *of his* Essays p. 250.

4. Those metallic plates, generally called *tin* by the English, and more properly *fer-blanc* by the French, are merely iron-plates, very thin, which, on being dipped in melted tin, become quite covered by it, and form a very useful material for making a great variety of vessels and utensils of general use: particularly kitchen vessels, sauce pans, and other implements for the purposes of dressing all sorts of food on the fire. These are the most wholesome vessels, and the only ones that can be employed with safety; whilst those made of copper are highly dangerous, even when newly tinned in the inside; for if any small corner, or part of the surface, escapes the attention of the workman, or if the covering wears out without being observed, some verdigrease may be there generated; and this, when taken with the victuals, never fails of causing terrible effects on the animal body, and often inevitable death. It is much to be wondered indeed! that

It is likewise worthy of observation, that when its ore is profitable, or to be worked to any advantage

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that the numerous disasters that repeatedly happen all over Europe and elsewhere, have not yet determined mankind to exterminate, absolutely, every sort of copper-vessels and all other utensils of copper from their kitchens.

5. It is certain that neither vegetable acids, nor distilled vinegar, dissolve any sensible quantity from tin; and it was on this account that copper vessels for culinary purposes, are generally tinned in the inside, to prevent the poisonous effects of verdegrease being produced, and mixed with the food prepared in such vessels; but, besides the deficiency already mentioned, that may happen in the tinning, the metal commonly employed for this purpose, consists of 5 parts of pewter and 3 parts of lead. Now it is known, that lead is easily attacked by vegetable acids; and if it happens to be taken internally, never fails of producing dangerous and chronic diseases, the *colica Pictonum*, *palsies*, &c. So that after due consideration, *tinned iron*, and *tin-plate*, are the only cheap and wholesome materials for vessels for kitchen use.

6. This tin-plate, last-mentioned, is nothing else, but sheets or plates of iron, that have been hammered, or, which is better, flattened to a proper thickness, by passing the hot iron between two iron cylinders cased with steel; they are then cut to a proper size, and steeped in a solution of sal-ammoniac, or in an acid liquor, produced from the fermentation of barley meal, though any other weak acid would answer the purpose; after this steeping, they must be well scoured, so that the whole surface may be very clean and quite bright. They are then dipped into an iron pot filled with melted tin, whose surface is covered with suet, or fat, and pitch. The plates come out with both the surfaces covered with the tin: and as they possess the cleanliness of the tin, added to the rigidity of the iron, they are of great use for many purposes of common life.

7. Pewter, which is commonly called *etain* in France, and generally confounded there with true tin, is a compound

advantage, it is always in form of an indurated calx, which resembles those glasses that are prepared from metallic calces in our laboratories.

Therefore, in speaking of this resemblance, in order to render this Mineralogical Essay more intelligible to the reader, I have used the term *calx*, in describing the metals; by which word is understood

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metal, whose basis is tin. The best sort consists of tin allayed with about a twentieth, or less, of copper or other metallic bodies, as the experience of the workmen has shewn to be the most conducive to the improvement of its hardness and colour, such as *lead*, *zinc*, *bismuth*, and the metallic, or reguline part of *antimony*. There are 3 sorts of pewter, distinguished by the names of *plate*, *trifle*, and *ley-pewter*. The first is used for plates and dishes; the second for the *pints*, *quarts*, and other measures of beer; and the lay-pewter is used for wine measures, and large vessels.

8. The best sort of pewter consists of 17 parts of regulus of antimony to 100 parts of tin; but the French add a little copper to this kind of tin. A very fine silver looking metal is composed of 100 pounds of tin, 8 of regulus of antimony, 1 of bismuth, and 4 of copper. On the contrary, the *ley* pewter, by comparing its *specific* gravity with those of the mixtures of tin and lead, already mentioned in the table at page 625, must contain more than a fifth part of its weight of lead. This quantity of lead is far too much, considering some of the uses this sort of pewter is applied to; for acid wines will readily corrode the lead of the flagons, in which they are measured, into sugar of lead, which being taken internally, is productive of various chronic diseases, as the *Colica Pictonum*, *palsies*, *stupors* in the limbs, &c.

9. Foreigners generally assert, that English tin is always a mixed metal when exported abroad: and the French Encyclopedists in particular (article *etain*) inform us, on the authority of Mr. Rouelle, that the English tin, when cast into moulds,

understood the same as the chemists call a *crocus*, or *terra metallorum privata*.

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The words here suppressed, related to the mistaken notion of the Author already mentioned in Note [c], to Sect. 302. p. 634.

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moulds, of 6 inches in thickness, and cooled, if it be divided into 3 layers, the uppermost has 3 pounds of copper on the 100 of tin: the second layer has 5 pounds of lead to the same quantity of tin; and the lowest layer has 9 of lead to the hundred of tin. Geoffroy had formerly given a similar account of the English tin, with some variety in the doses. But there never was any other foundation for such an assertion, than that *pewter* has been mistaken for *tin* abroad: and in fact all pewter-dishes and all other pewter-pieces are called by the name of tin-ware all over Europe, except in England. Nor could there ever be any advantageous motive to hinder the export of pure tin from England, where it is found in a greater abundance than any where else. Besides the above, neither Borlase nor Pryce, who wrote so minutely on the method of preparing tin in Cornwall, mention any operation or mixtures this metal undergoes or receives, before or after it is cast into the slabs, blocks, or pieces of tin, in which *size*, and *form*, it is sold, and sent to every market in Europe; so that the whole must be a mistake in terms, as already mentioned, by taking *pewter* simply for tin.

10. The calx of tin, known by the name of *Putty*, is generally used to polish various hard bodies, as glass, metallic specula for reflecting telescopes, &c. When fused with lead and sand it produces enamel; and serves also to cover earthenware, giving to it a glassy and neat surface for use. *The Editor, chiefly from Watson's* Essays.

SECT. 305. (184.)

Lead. *Plumbum*, *Saturnus*, Lat. *Bley*, Germ. *Bly*, Swed. *Plomb*, French.

General Properties of Lead.

a. This metal is of a blueish white colour when fresh broke, but soon becomes dull or tarnished in the air [*a*].

b. Is very heavy; viz. to water as 11,325 to 1000 [*b*].

c. Is the softest next to gold, but has no great tenacity, and is not in the least sonorous [*c*]. It

[*a*] Lead is not subject to be much corroded by exposure to air or water; though after long standing, a thin crust is formed on its surface, which is a true calx of lead formed by the aerial acid, that slowly decomposes it. *Mongez.*

[*b*] According to Bergman, the specific gravity of lead is=11,352: Kirwan says, however, that it reaches from 11,300 to 11,479. According to Watson, an English cubic foot of new lead weighs 11,262 ounces of *avoirdupoids*; but of lead reduced from *minium*, it weighs 11,460. See the table at page 625.

[*c*] The Author means undoubtedly, that lead is the softest of all metals, except pure gold, with regard to its pliancy or flexibility; but its tenacity is very inconsiderable; and consequently it is incapable of being drawn into a fine wire.

Under the hammer, it is easily extended into thin plates; but its properties, as Nicholson observes, have not induced practitioners *d.* It is easily calcined; and, by a certain art in managing the degrees of the fire, its calx becomes white, yellow, and red [*d*]. This

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practitioners to subject it to the same trials as *gold*, *silver*, and *copper*. A wire of this metal, *one-tenth of an inch* thick, cannot hold a weight above 29 pounds and a quarter, without breaking. *Mongez.*

Lead has a remarkable smell, which is very distinctly perceived when rubbed. *Fourcroy.*

[*d*] Lead, mixed with tin, calcines sooner than by itself alone: one pound of this last quickly incinerates 10 pounds of lead. *Neumann.*

By calcination, lead is converted into a dusky powder called *plumbum ustum*; a longer continued heat, with access of air, renders it *white*, *yellow*, and afterwards it becomes of a *bright red*, inclining to *orange colour*, called *minium*, or *red lead*. The heat for this purpose must not exceed a certain degree. A greater heat converts this substance by degrees, into a *yellow* flaky calx, called *Litharge*; and, by a moderately strong fire, it runs into a *yellow transparent* glass, which powerfully dissolves metallic calces; and, unless combined with these, or earthy additions, corrodes and passes through common crucibles. This glass acts more strongly on *siliceous* than on *argillaceous* earths, and is a principal ingredient in fine white flint-glass. *Nicholson.*

The red-lead, or *minium*, may be made directly from *lead*, and also from *litharge*, which has already been said to be the half vitrified calx of the same metal, and can be had cheaper from various processes where lead is employed. But this last red lead is not so good as the former, on account of the scoria of other substances mixed therewith; particularly the makers of flint-glass, who use much red-lead in the composition of that glass, find that it does not flux so well as that made from the direct calcination of the metal, as practised in the county of *Derby*, where no less than nine mills or furnaces are kept on this operation. These furnaces are very like a baker's oven, with a low vaulted

e. This calx melts more eafily, than any other metallic calx, to a glafs, which becomes of a yellow colour, and femi-tranfparent. This glafs brings other bodies, and the imperfect metals, into fufion with it,

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vaulted roof, and two party-walls, rifing from their floor, which leave a middle fpace, where the pit coal is burned: the flame being drawn over the party walls, ftrikes on the roof, and is from thence reflected on each fide, by which the lead there kept is melted. The furface of lead, by its expofition to air, becomes inftantly covered with a dufky pellicle; this is fucceffively removed, and the greateft part of the metal is converted into a yellowifh-green powder. This is afterwards ground fine in a mill, and wafhed; the heterogeneous particles of lead, ftill in being, are feparated by paffing the wafh through fieves: the yellow colour becomes uniform, and is called *Mafficot* by the painters. Thefe yellow calces, being well dried, are thrown again into the furnace, where they are conftantly ftirred in a continued heat; fo that in about 48 hours, thefe calces acquire a *vivid red* inclining to *orange colour*, and are known by the name of *Minium*, or *red-lead*. Mr. de Machy was certainly miftaken, when he afferted that the calcination alone, without the contact of the flame and fmoke, was capable of producing a good colour. But the red-lead made in France is of a confiderably worfe quality, than what is made in England, or Holland. A ton, or 20 hundred weight of lead, generally gives 22 hundred weight of minium. It is faid, that at Nuremberg the increafed weight of red-lead amounts to one-fifth of the metal; this may probably depend on the method employed, as Watfon thinks. Neumann fays, that the beft Venetian minium is made out of ceruffe, or white lead.

The litharge, already mentioned, is called *Litharge of Gold*, when its colour inclines to *yellow*; and of *filver*, when it is *whitifh*; but neither of them contains any portion of thefe precious metals. *Neumann*.

It

f. It diſſolves, 1ſt, in the ſpirit of nitre; 2dly, in a diluted oil of vitriol, by way of digeſtion; 3dly, in the vegetable acid; 4thly, in alcaline ſolutions; and 5thly, in expreſſed oils, both in the form of metal and of calx [*e*].

g. It gives a ſweet taſte to all ſolutions.

h. It amalgamates with quickſilver.

i. With the ſpirit of ſea-ſalt it has the ſame effect as ſilver, whereby is produced a *ſaturnus corneus* [*f*].

It

[*e*] Lead diſſolves in *nitrous acid* into a yellow liquor. This ſolution inſpiſſated, explodes or fulminates in the fire. *Neumann.*

Proof *aqua fortis*, lowered with an equal quantity of water, diſſolves half its weight of lead. This ſolution, according to Lewis, being diluted with water, becomes milky, and depoſits the metal. But Fourcroy denies this fact in his vol. I. p. 512 of the Engliſh edition. The ſame ſolution, after exhaling very ſlowly to the air part of the menſtrum, ſhoots into ſmall pyramidal cryſtals with ſquare baſes, of an auſtere ſweet taſte. *Lewis.* Fourcroy ſays, that theſe pyramids are hexaedral.

Vitriolic acid, aſſiſted by a boiling heat, corrodes half of its weight of lead into a ſaline maſs. This acid precipitates the metal from its *nitrous* and *marine* ſolutions. *Lewis*, and *Kirwan.*

[*f*] Pure marine acid, with the aſſiſtance of heat, readily calcines lead, and diſſolves part of its calx; but it is difficult to ſaturate it compleately. By a ſtrong evaporation, it produces cryſtals in the form of fine and brilliant needles, according to *Monet* quoted by *Fourcroy.* This metal combines more readily and intimately with marine acid, when this menſtrum is poured either uncombined or united with an earthy or alkaline baſe, into the ſolution of lead in nitrous acid.

 A copious

k. It does not unite with iron, when it is singly added to it in the fire.

l. It works on the cuppel, which signifies that its glass enters into certain porous bodies, destitute of phlogiston, and alcaline salts.

It

A copious white precipitate is then immediately formed, resembling a coagulum; which is a new combined salt, that falls down, on account of its great insolubility. If exposed to the fire, vapours of a saccharine taste are disengaged: and it fuses into a brown mass, called *Plumbum Corneum*. Fourcroy.

The acetous acid dissolves lead and its calces. *White-lead*, or *ceruse*, is made by rolling leaden plates spirally up, so as to leave the space of an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered and exposed for a length of time to a gentle heat, in a sand-bath; or else they are covered with dung. The vapour of the vinegar attaches itself to the surface of the plates, and corrodes them, reducing the same by that means into *ceruse*, which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly, till they are corroded through.

The acid in the *ceruse* is super-saturated. By a solution of this compound in acetous acid, a crystallizable salt, called *sugar of lead*, is obtained, which is the same as would, with less facility, have been procured by dissolving lead directly in that acid. *Nicholson.*

All solutions of lead are precipitated black by the *liver of sulphur*: and then a sort of *Galena* is formed, the sulphur being deposed upon the calx of lead; which seems to indicate, that the lead, in this ore, is in a calciform state. *Fourcroy.*

The calces of lead are much affected by sulphureous vapours of all kinds. Even metallic salts, which have lead for their base, especially *saccharum saturni*, change colour by the vicinity of such vapours. This solution of sugar of lead may serve as a sympathetic ink. A letter written with it, on being exposed to the vapour of sulphur on lime-water; the invisible *m.* It melts in the fire before it is made red-hot, almost as easily as tin [*g*].

Its

invisible vapours that rise from it, will blacken the writing, although the letter be put between two or three hundred leaves of paper.

Oils and fats have a strong action on lead, and its calces. Litharge, or any other calces of lead, are copiously and intirely soluble in oils by boiling, which are thereby rendered thicker, and more drying. Linseed oil, thus impregnated with litharge, is much used by painters on the account of the last quality: and is known under the name of *drying oil.* Many of the plasters used in surgery have for their basis an oil thickened by boiling with calx of lead. *Nicholson.*

The topical preparations of calces of lead, known by the name of *Goulard*, have performed wonderful cures in numberless cases, in which other applications have failed. *See the excellent Treatise of Goulard, in* 12mo. *London*, 1775. *The Editor.*

[*g*] Lead melts easily on the fire, long before its ignition, at about 595 degrees of Fahrenheit's thermometer, according to Bergman: but Lewis and Nicholson affirm, that 540 degrees is sufficient for the purpose: and that at this degree, its calcination will begin, if respirable air be present in the operation.

By the union of lead with tin and bismuth in a due proportion, a compound metal results, which melts below the degree in which water boils. This mixture has been published by Dr. d'Arcet the celebrated professor of chemistry at Paris. It consists of three parts *tin*, five of *lead*, and eight of *bismuth*. The doses given by Newton, who first discovered this kind of metallic mixtures, and those given by Margraaf and Homberg, require a higher degree of heat to melt. *See Journal de Physique* for March 1777, page 217.

As soon as pure lead melts, its surface is covered with a pellicle, which exhibits various successions of colours; but a small portion of tin or zinc, mixed with it, prevents this variegated appearance. The lead of those metallic sheets, with which the Chinese boxes of tea are lined, does not exhibit, *n*. Its calx or glass may be reduced to its metallic state by pot-ashes.

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hibit, when melted, those variegated colours on its surface, no doubt on account of its mixture with other metals. The order in which these colours succeed one another, is the following; *yellow*, *purple*, *blue*, then *yellow*, *purple*, *green*, and twice *pink-green*. All these colours are very vivid with a proper heat; but if that is weak, that succession of colours stops before it has gone through all the above changes. *Watson*.

Melted lead, in a strong red-heat, boils and emits fumes, which the workmen erroneously call *Sulphur*, for they are nothing else but the calcined parts of the metal that sublime of a yellow and red colour. Watson affirms, in his essays, vol. III. p. 344, that this sublimate amounts to about *five hundred* weight in one hundred *tons*; viz. 500 in 200,000 pounds, or ¼ *per centum*.

If melted lead be poured into a box, previously rubbed with chalk (to prevent adhesion) and continually agitated, it will concrete into separate grains, of considerable use in a variety of mechanical operations; or, if it be poured into a mould, and turned out at the instant of cooling, a blow with a hammer will break the mass, and the symmetrical arrangement of the internal parts will be seen. *Nicholson*. The like happens also to tin in similar circumstances, as was noted at p. 619.

When melted lead is suffered to cool very slowly, it crystallizes into quadrangular pyramids, laying sideways one over the other. But all metallic substances have been found to have their particular crystallization, of which that of metals approaches to the pyramidical form, whilst that of the semi-metals affects the form of needles, provided they be all properly managed in their cooling, as Mongez has shewn in the *Journal de Physique* of July for 1781, p. 74. *The Editor*.

SECT.

SECT. 306. (Additional.)

Native Lead. Plumbum Nativum.

Our Author, in the Sect. 191. of this mineralogy and some other mineralogists, doubted whether *native lead* was ever found in its metallic state on the earth; but they never could shew any better grounds for their incredulity, than the deficiency of information; facts however are stubborn witnesses, which cannot be defeated by mere assertions [a].

It appears by the *Phil. Transact.* for 1772, *pag.* 20, that some small pieces of *native lead* were found in Wales, in the County of *Monmouth.*

Gensanne, in his *History of Languedoc*, p. 208, of vol. III. asserts also, that this metallic substance was found native in the Vivarais. Henc-

[a] Bomare mentions (in his *Mineralogy*, vol. II. p. 176.) a curious specimen of *native lead*, kept in the collection of Abbé Nolin at Paris, that had been found in the lead-mines of *Pompean*, near *Rennes* in Brittany. This metal was very malleable; could be cut with a knife without crumbling and easily melted over the flame of a candle. It weighed about two pounds; was imbedded in an earthy lead-ore of a reddish colour: and had a slaty vein that went through it. I think, that after such circumstances it can hardly be doubted of its being a natural production. *The Editor.*

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kel affirms likewise its existence, in his *Flora Saturnisans*. See Kirwan's *Elem. of Mineralogy*, p. 297 and 298.

Wallerius (p. 301, of the 2d vol. of his Minerallogy,) asserts, that this metal has been found in its metallic form, in Poland, a specimen of which was kept in the collection of Richter; and adds, that a similar one, found at Schneberg, was seen in the collection of Spener.

Dr. Lawson, in his English edition of Cramer's *Art of Essaying Metals*, says, at p. 147, that some *pure native malleable lead* had been lately found in *New England*.

And lastly, the late celebrated Professor Bergman did not hesitate to insert, by itself alone, the *plumbum nativum*, in Sect. 180, of his *Sciagraphia*.

SECT. 307. (185.)

Calciform Lead.

Lead is found,

A. In the form of a calx, *Minera plumbi calciformis* [a].

Pure,

[a] The calciform ores of lead may be distinguished into 5 varieties; *viz.* 1. The *white*, *lead-spar*, *lead ochre*, *native ceruse*. 2. *Red*, *brown*, or *yellow*. 3. *Green*. 4. *Bluish*. 5. *Black*. All are mineralized by the *aerial acid*, or *fixed air*: are

1. Pure, *Minera plumbi calciformis pura.*

a. Friable, lead ochre; *Cerussa nativa*, Native ceruse, is found at Kristiersberget in Westmanland, on the surface of the potter's ore [*b*].

b. Indurated, lead spar, or spatose lead ore, *Spatum plumbi.*

1. Radiated, or fibrous.

White, from Mendip-Hills, in England [*c*].

Cristallised

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are soluble in nitrous acid, and effervesce with it, if heat be used; and are dissolved also in expressed oils. All contain a little iron, but never any silver.

[*b*] Lead ochre, or native *ceruse*, is the same substance; but either in a loose form, or indurated, and shapeless; sometimes it is found in a filamentous form, of a silky appearance. Both contain a little iron, and sometimes calcareous and argillaceous earth: grow red or yellow when sufficiently heated. They effervesce with acids, and afford from 60 to 80, or 90 *per centum* of lead; both are found in *Brittany*, *Lorrain*, *Germany*, and *England*. Kirwan.

Bergman made a separate section of this *cerusa nativa*, which is nothing else but this white lead-ore, mineralized by the aerial acid. *See the Sect.* 183, *of his* Sciagraphia.

[*c*] It is there found with the iron-stone and Manganese; but in small quantities. Likewise at Zetterfield in the Hartz. *Brunnich.*

Mr. Sage of the Royal Academy at Paris, pretended that the *white* lead ore, from Poulawen in the county of Bretagne in France, was mineralized by the *marine acid*: but this assertion was demonstrated to be absolutely erroneous by the commissioners of that Academy. *See* Journal de Physique. Tom. III. p. 348. for June 1774.

This ore, according to the same Academicians, is composed of striated crystals, of a whitish pale red, or grey colour. There is a *white lead-ore*, sometimes *grey*, and sometimes yellow

2. Criſtalliſed in a priſmatick figure [*d*].

a White, from Norrgrufva in Weſtmanland.

Yellowiſh

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yellow, which is very heavy. Its ſtructure is either lamellated or fibrous, and its laminæ can hardly be ſeparated; but is friable, and may be cut with a knife. Sometimes it is cryſtallized, and ſometimes its fibres are extremely thin, ſemi-tranſparent, and of a ſilky look, as deſcribed in the preceding note. They effervesce with acids, decrepitate on the fire, and ſeem to looſe the aerial acid, by which the lead is mineralized. Among the lead mines of France, England, Saxony, and other parts of Germany, many fine ſpecimens of this ore are often to be met with. *Mongez.*

[*d*] The ſparry lead has often a ſemi-tranſparency like the ſparry fluor; its cryſtals are generally truncated hexaedral priſms, or cylindrical columns, ſtriated, and ſeem to be compoſed of a great number of filaments; theſe ſparry cryſtals are always found in the ſame places with the *galena* or ſulphurated lead ores; and ſeem to be formed from their decompoſition, after the loſs of their ſulphur; for it is not rare to find galenas, which are beginning to paſs to the ſtate of white-lead.

Therefore the *black ore* of lead may be regarded as an intermediate ſpecies between the *white lead* and *galena*, as it ſeems to be a true white lead altered by the hepatic vapours of the ſulphur, on its parting from the galena.

The *green ſparry lead* is more or leſs tranſparent, and for the moſt part yellowiſh. It has frequently no regular form, and appears like a kind of moſs.

Theſe lead-ores are found chiefly in Hoffsgrund, and near Friburg in Briſgaw. When this green ore is criſtallized, it conſiſts of hexaedral truncated priſms, terminated by ſix-ſided pyramids, either intire, or truncated near their baſe. A great quantity of it is found at Sainte Marie-aux-mines, and at Tſchoppau in Saxony. *Fourcroy.*

The *green* and the *black* from Saxony, as well as the *blue* from Hungary, are priſmatic. *Brunnick.*

b. Yellowish green, from Zchopau in Saxony [*d*].

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[*d*] The *green lead ores* are either cryſtallized in needles, as in *Brittany*, or in a looſe powder as in *Saxony*; but moſt adhering to, or inveſting quartz. They owe the green colour to iron, ſeldom contain copper, and are very rare. *Kirwan* and *Mongez*.

Sapphire coloured. This was once found, together with ſome white-lead-ſpar, at *Wendiſh-Leuten*; and could be eaſily melted by the blow-pipe. Dr. Jacquin had this curioſity in his cabinet. *Brunnich*.

This lead ore is ſometimes cryſtalized, ſometimes amorphous; it owes its colour to a mixture of copper. *Kirwan*.

Black. This ore is found, though very ſeldom, in Saxony.

The figure of theſe cryſtals is not always the ſame. The *white* ones come near to the ſhape of the ſelenite.

Red, or *natural minium*, was found in Siberia: and a ſpecimen of it was kept in the collection of the late Prince Charles de Lorraine at Bruxelles. *Fabroni*.

Another *red lead* was found in the mines of Piroſew near *Catherinenburg* in Siberia. *Brunnich*.

The *red*, *brown*, or *yellow* lead-ore, is found either regularly cryſtallized, or in ſhapeleſs maſſes, or in powder. It differs from the white ſpar, and from the native ceruſe, only by containing more iron. That in powder, contains a mixture of clay. *Kirwan's* Mineralogy p. 299. See alſo what has been ſaid in the note at p. 524.

Dr. J. R. Forſter brought from Ruſſia ſome of this cryſtallized red lead ore, which I ſaw on his firſt arrival in England. They appeared to be nearly of a cubical form, and the red-colour was rather pale. *The Editor*.

The *red* Siberian ones are perfectly rhombic; and the *green* from Bohemia have a cubical or rhomboidal form. Their colour depends on the adventitious particles. Lehman has found ſulphur and arſenic in the *red* ones: the others have not been ſufficiently inveſtigated: moſt of them efferveſce with acids. *Brunnich*.

The

SECT. 308. (186.)

Minera plumbi calciformis mixta.

a. Mixed with the calx of arsenic, *arsenical lead spar.*

1. Indurated.

a. White. I have tried such an ore from an unknown place in Germany, and found that no metallic lead could be melted from it by means of the blowpipe, as can be done out of other lead spars; but it must be performed in a crucible, and then that part of the arsenic which did not fly off in smoke, during the experiment, was likewise reduced, and found in form of grains dispersed, and forced into the lead.

Another ore of this kind, which likewise was not easily reduced by means of the blowpipe, did always after being melted, and during the cooling, hastily shoot into polygonal,

The *black-lead ores* are the most uncommon of all; and occur either crystallized, or of an indeterminate form. *Kirwan.*

A lead ore of a *purplish brown*, nearly resembling the flower of the *peach-tree*, was found at Huelgoet in Brittany. It was a needle-formed crystallization; difficultly fusible with the blow-pipe, and contained more iron than others; but it was easily reduced by the mineral alkali. *Mongez.*

gonal, but mostly hexagonal crystals, with shining surfaces. Can this crystallisation be owing to salts, which are said not to act in this manner, but when they are dissolved in water?

b. With calcareous earth [*a*].

[*a*] This is the lead ore, described *Minera calciformis mixta terra calcarea majore portione*, of which our author has already treated in his Sect. 37 and 38. It effervesces with aqua fortis, and contains 40 *per cent.* of lead; on which account, it ought rather to be placed here than among the calcareous earths. M. Cronstedt founded his classification upon the Swedish minerals. There are in Scotland, and the northern provinces of England, indurated lead-ochres; but, for want of sufficient experiments, their places in the system are still uncertain. *Brunnich.*

The abovementioned ores are very rich in lead, and easy to be tried; most of them, being slowly heated, may be reduced to lead, by means of the blow-pipe, on a piece of charcoal. The calx of the lead in these ores has, perhaps, first been dissolved by sulphur and arsenic, and afterwards, when these two have weathered away or decayed, have assumed this form; in the same manner as we see it really happens during calcination, with rich lead ores, or such reguli as contain lead. The same, very probably, is the case with other metals; for which reason their ores, when they occur in form of a calx, often contain a little sulphur, and more especially arsenic. *The Author.*

N. B. Most of these ores, mentioned in the notes to the preceding section 307, might as well have been treated of in this place; but it was thought better to set them down according to the references pointed out by Professor Brunnich. *The Editor.*

SECT. 309. (187.)

Lead mineralized. *Plumbum mineralisatum.*

1. With sulphur alone, *Plumbum sulphure mineralisatum*: The *Bley-Schweiff*, or *Bley-glanz*, of the Germans.

a. Steel-grained lead ore, from the mines at Hellefors, in the province of Westmanland.

b. Radiated, or antimoniated lead ore.

c. Tessellated, or potters lead ore.

At Villach in Austria there is said to be found a potters lead ore, which contains not the least portion of silver.

SECT. 310. (Additional.)

Lead mineralized by the Vitriolic Acid.

This ore was discovered by Mr. Monnet. It occurs sometimes, though rarely, in the form of a white ponderous calx.

It is soluble in 16 or 18 times its weight of water.

Does not effervesce, nor is it soluble in other acids.

It may be reduced, by the blow-pipe upon charcoal.

It

It seems to originate from the spontaneous decomposition of the sulphurated lead ores mentioned in the last Section.

According to Dr. Withering, another variety of this ore of lead mineralized by *vitriolic acid*, is found in great quantity, in the island of *Anglesey* near Carnarvonshire in England: but it is united to *iron*; and is not reducible by the blow-pipe over charcoal. It is of a yellow colour, and contains some clay. The Doctor promises an accurate analysis of this ore. *The Editor from* Kirwan, *and* Bergman.

SECT. 311. (Additional.)

Lead mineralized by the *Acid of Phosphorus*.

This ore was lately discovered by Gahn.

It is of a greenish colour, by reason of a mixture of iron.

Melts upon the charcoal, with the blow-pipe; but does not effervesce with acids.

After solution in nitrous acid, with heat, the lead may be precipitated by vitriolic acid. 137 *grains* of this precipitate, after being washed and dried, afford 100 *gr.* of lead in its metallic state; and the decanted liquor, being evaporated to dryness, produce the *phosphoric acid*: which being mixed with powder of charcoal, affords real phosphorus by distillation.

A ſmall piece of this ore, being melted by the heat of a flame, urged by the blow-pipe, aſſumes the form of a polyedral globule, whoſe facets, though apparently flat, are really compoſed of concentric ſtriæ, when obſerved by the microſcope.

Seven ounces of this green lead-ore from Hoffsgrund, near Friburg, capital of Briſgaw, in Swabia, being powdered, and diſſolved in the nitrous acid, on adding vitriolic acid, this united with the lead, and both precipitated: the remaining liquor being evaporated on a ſand heat, to the conſiſtency of Syrup, which was of a green colour, was mixed with powdered charcoal; and, on being urged by fire in a retort, produced about two gros (144 *gr.*) of a fine phoſphorus.

A ſimilar compound may be ſynthetically produced, if *pure* phoſphoric acid, (*viz.* combined with volatile alkali, for the natron of the microcoſmic ſalt hinders the production) be mixed with red-lead. *The Editor from* Bergman, Kirwan, and Mongez.

SECT. 312. (188.)

2. Lead with ſulphurated ſilver. *Plumbum argento ſulphurato mineraliſatum.* Galena: Alſo called *Bleyglanz* by the Germans.

a. Steel-grained, is found in the mines of Salberg and Hellefors, in the province of Weſtmanland;

Westmanland; and in the Dorothea-mine, on the Hartz in Germany.

b. With small scales, is found at Salberg, and is there particularly called *Blyschweif.*

c. Fine-grained, found at Salberg.

d. Of a fine cubical texture; and,

e. Of coarse cubes. These two varieties are found in all the Swedish silver mines.

f. Crystallized, from Gislof in the province of Skone [a].

SECT.

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[a] The steel-grained and scaly ores are of a dim and dull appearance when they are broken, and their particles have no determinate angular figure: they are therefore in Swedish commonly called *Blyschweif*, in opposition to the cubical ores, which are called *Blyglanz.*

But, in my opinion, the ores ought to be denominated, and distinguished from one another according to their metallic contents. No ore ought, according to the most received usage, to be called *Blyschweif*, but that which contains only lead and sulphur.

Most part of the ores called *Blyglanz* contain silver, even to twenty four ounces per cent. of which we have instances in the mines of Salberg, where it has been observed that the large diced lead ores are generally the richest in silver, contrary to what is commonly taught in books; the reason of which may perhaps be, that, in making the essays on these two ores, the coarse cubical can be chosen purer or freer from the rock, than the fine cubical ores. *The Author.*

The *galena*, *potter's ore*, *bleyglanz*, and *bleyshweif*, are the commonest of all lead ores. They are of a blueish dark lead colour, formed of cubes of a moderate size, or in cubic grains, whose corners appear to have been cut off. Their texture is lamellar, and of a variable hardness. The hardest sort contain a large proportion of iron and quartz. Those in grains are the richest in silver, and contain about 1 or 1,5 *per cent.*

that is, 12 or 18 *ounces* per quintal; the pooreſt, about 60 *grains*. Ores that yield about ½ an ounce of ſilver per quintal, are hardly worth the coſt of extracting it. *See note* [*b*] *to p.* 544.

The proportion of ſulphur to lead in this ore is alſo variable, within the limits of 15 and 25 *per cent.* That which contains the leaſt, is called *bleyſchweif*, and is in ſome degree malleable. The proportion of lead is from 60 to 85 *per cent.* by reaſon of an accidental mixture of quartz; and that of iron is generally very ſmall. It was aſſerted by Monnet, that ſulphurated lead ores are inſoluble in nitrous acid. Watſon affirms, that dilute nitrous acid diſſolves them completely.

The ſpecific gravity of galena is from 7000 to 7780; when it is melted, it yields a yellow ſlag. *The Editor chiefly from* Kirwan.

Galena is found alſo in a *maſſy form* without any regular figure. This kind is very frequent at *Sainte Marie aux Mines*.

Galena, with large *facets*, not forming any regular cryſtals, and quite entirely compoſed of laminæ, is a very common ore.

That in *ſmall facets*, appears like mica, and conſiſts of ſmall, white, and very brilliant ſcales. It is called *white ore of ſilver*, becauſe it contains a great quantity of this metal. Such is that of the mines of Pompean in Brittany.

The galena in *ſmall grains*, mentioned by the author, is very rich in ſilver.

There are few, except that of Carinthia, which are fonnd not to contain ſilver, almoſt all others containing more or leſs.

It deſerves to be noticed, that galenas whoſe facets or grains are the ſmalleſt, yield in general the greateſt quantity of ſilver. It ſeems that the ſilver being in ſome meaſure a body foreign to the combination of *galena*, deranges the regular cryſtallization of this ore. *See Sect.* 278. p. 561 *on the* ſilver--potters-ore.

Galena ſtriated, like antimony, has the external appearance of maſſy galena; but its fracture exhibits flat and brilliant needles, like that ſemi-metal.

Finally, galena, cryſtallized like ſparry lead, in hexagonal priſms, or cylindrical columns, is found in the mines of Huelgoet

SECT. 313. (189.)

3. With sulphurated iron and silver, *Plumbum ferro & argento sulphurato mineralisatum* [a], is found,

a. Fine-grained.
b. Fine cubical.
c. Coarse cubical. These are found at Westersilfverberget, in Westmanland.

When this ore is scorified, it yields a black slag; whereas the preceding lead ores yield a yellow one.

Huelgoet in Lower Britanny. This is not rich in silver, and seems to be merely some sparry lead which has been mineralized by sulphur, without having suffered any alteration of form: and indeed there are sometimes observed, upon the same piece, crystals of pure sparry lead, intirely covered with a very fine galena, and others which are quite changed into galena, even in the inner part of their prisms. *Fourcroy.*

[a] The lead ore, described by Kirwan, in his Spec. 7. p. 305, as mineralized by *sulphur* with *silver*, and a large portion of *iron*, called *pyritous lead-ore*, seems to be the same with that described by our Author in this section. Kirwan says, that it is nothing else but a mixture of galena.

The ore, called *pyriteous lead ore*, is merely a mixture of galena with *brown pyrites*, of which hereafter among the iron-ores. This is of a brown, or yellowish-dark colour; of an oblong or stalactical form; and of a lamellar, striated, and loose texture. It contains a large portion of of iron, and affords at most 18 or 20 *per cent.* of lead, which flows by barely heating it in the fire, as the iron detains the sulphur, allowing the lead to run off. *The Editor from* Kirwan.

SECT. 314. (190.)

4. With sulphurated antimony and silver, *Plumbum antimonio et argento sulphurato mineralisatum.* Antimoniated or radiated lead ore. This has the colour of a Blyglanz, but is of a radiated texture. It is found,

a. With fine rays or fibres, and,
b. With coarse rays or fibres.

And is found in Maklos Schacht and Fierde-Bottn, in the mine of Salberg in Westmanland. The lead in this ore prevents any use being made of the antimony to advantage, and the antimony is likewise very injurious in the extracting of the silver [*a*].

SECT. 315. (Additional.)

Lead mineralized by Arsenic.

This ore was lately discovered in *Siberia*. Externally it is of a pale, and internally of a deep red colour.

[*a*] This lead-ore, when heated, yields a white smoke; and affords 40 to 50 *per cent.* of lead, and from ½ to 2 ounces of silver in the quintal. *Kirwan.* This is found also at St. *Marie aux mines.* Mongez.

For

For the moſt part it is criſtallized into rhomboidal paralellopipedes, or irregular pyramids.

According to Lehman it contains *ſulphur*, *arſenic*, and about 34 *per cent.* of *Lead.* Mr. Pallas ſays that it contains alſo ſome ſilver.

It was found near *Catherineburg* in *Siberia*: and Lehman ſays, that on being reduced to powder, it reſembles the beſt carmine.

Mongez examined ſome, which on the outſide was of a yellow-greeniſh colour; this had been found among quartz in the ſame country, and contained alſo ſome arſenic.

Both theſe varieties may be eaſily reduced by the heat of a blowpipe. *The Editor.*

SECT. 316. (Additional.)

Stony, or Sandy Lead Ores.

This ore conſiſt either of the *calciform*, or of the *galena* kind, intimately mixed, and diffuſed through ſtones and earth, chiefly of the calcareous, or of the barytic genus. *Kirwan.*

Of this ſpecies ſeems to be the earthy lead-ore, falſely called *Native Maſſicot*, found in the lead mines of Pompean in Britany, in the form of ſolid pieces; they are either yellowiſh or grey: appear bright like glaſs when broken: effervefce with acids: whence it appears that this ore is mineralized by the aerial acid, and ſometimes it is mixed with clay. *Mongez.*

SECT.

SECT. 317. (191.)

Observations on Lead Ores.

I know of no native lead; and all that has been said respecting it, is liable to considerable objections. (*See Sect.* 306.)

Such of the potters ores as do not contain any silver are very scarce; yet they are often found so poor in silver, that it does not answer the expences of extracting. These, when they are free from mixtures of the rock, are, without any previous fusion, employed to glaze earthen-ware; and a great trade is carried on in the Mediterranean with such ores, from the lead-mines of Sardinia and France [*a*].

[*a*] 1. In Hungary and Transilvania, the lead-ore contains, besides the silver, a considerable quantity of gold.

Whether lead be mineralized with more metallic bodies than those already mentioned in the preceding Sections, is as yet unknown. The mine of Morgenstern, at Freyberg, has a peculiar variety of lead ore, containing silver, which deserves to be noticed on account of its yellowish-brown colour; and likewise on account of its singular figure, which consists of slender cylinders. *See note* [*b*] *to p.* 544, *on the* silver *generally contained in* lead ores.

2. Sometimes it is found growing in dendritical forms, like the *knit-cobalt*.

At Goslar they call a lead ore, mixed with blend, *Brown lead-ore*. Brunnich.

3. Lead

3. Lead unites by fusion to most other metals. A small addition of it makes gold and silver brittle; though a proportional addition of either of these last to lead has the contrary effect, and makes it more ductile. Copper does not unite with lead, unless the lead be red-hot and boiling. After this union, it may again be separated by using a gentle heat, which melts the lead only, which runs off, and leaves the copper. This mode of separating metals by means of their different degrees of fusibility, does not succeed in various other metallic mixtures when fused together.

4. Lead does not unite with iron; but if both are exposed to the fire in a proper vessel, the lead is converted into litharge, which attacks and corrodes the iron, by seizing its phlogiston; and afterwards reduces the martial calces into a dark-coloured glass.

5. This property, which lead possesses, of reducing all imperfect metals into a glassy slag, is the means used to purify gold and silver, neither of which can be thus deprived of its metallic character, but remains untouched at the bottom of the coppel. This process is the more complete, from the efficacy of glass of lead to dissolve all earthy bodies, it being so powerful a flux, that no earthen vessel or crucible can contain it when fused, of whatever materials the vessel be made. A mixture of raw and burned clay stands the action of lead for the longest time; but its sides are also at length corroded.

6. Litharge is employed in the composition of all the finer glasses, called *Pastes*, which imitate *precious stones*. The addition of litharge makes them more solid and brilliant; and enables them to disperse the different coloured rays in a greater degree. The purest flint, purified alkali, borax, and litharge, are the chief and essential ingredients; the other additions, chiefly of metallic calces, are made only for the sake of tinging them of various colours.

7. The white or crystalline glass, called by the name of *flint-glass*, contains a large proportion of lead, which communicates a greater degree of ductility, and a sort of unctuosity, which renders it easier to be worked and polished, &c. It is the purest calx of lead called *minium*, made immediately from the metal, and the most pure *quartzous sand*, with pure *mineral alkali*, or still better with good *nitre*, that produce, when

when properly melted, the best flint-glass. The greater the proportion is of *red-lead*, the heavier is the glass, and of course its refraction is greater; an essential requisite to be employed in forming the compound achromatic object lenses for astronomical purposes. It must, however, be observed, that glass made with lead has the defect of being of unequal density, for want of a perfect mixture of all its parts; so that it is extremely difficult to find pieces of a few inches diameter among hundreds weight of this flint-glass, that shall be quite free from the filaments and striæ in the inside of the plate. It was by a great chance that the famous Dollond got once a pot of pure flint glass, from which he made the admirable triple object lenses of three feet and a half foot focus, that are in the hands of various astronomers both at home and abroad. But there are already near 20 years that no similar chance has happened again. Many attempts have been made in England and other parts of Europe to remedy this inconvenience; repeated and very considerable premiums have been offered to find the method of producing the fittest kind of this flint-glass for optical instruments; but they have not yet succeeded according to the public expectation.

8. Lead is of very extensive use, as when employed in sheets of a proper thinness for covering buildings, for making pipes to convey water, cisterns or reservoirs for keeping the same; to make statues and busts for the ornament of gardens, for securing iron bars in hard stones, and for sundry kinds of vessels for evaporation, &c.

9. Sheets of lead are made by passing this metal, whilst cold, between two cylinders, or rollers of iron, by which means their thickness is rendered quite uniform, as smooth as the rollers themselves, and of the desired thinness. This is called *milled lead*; but it is harder, and more brittle, than cast sheet-lead, which may be safely bent in any way without forming any crack. Doubtless this is the reason why plumbers say, that *milled lead*, although it may form a neater and lighter work, will not last so long. The *cast sheets* of lead are made by pouring this metal, when fused, upon the top of an inclined flat table, or mould formed with lateral rising borders. If the sheets are required to be thin, the bottom is covered with a woollen, and above this a linen cloth, which is not burned nor scorched thereby. The melted lead being

being received in a wooden case without a bottom, and of the same width of the table, this case is drawn down over the sloping bottom by a man at each side, and leaves a sheet, more or less thin, according to the degree of the velocity of its descent. But for making thicker sheets of lead, the bottom of the said mould or table is covered with wet sand, and the fused metal is conducted over it by a wooden strike, which bears on the borders of each side.

10. Common shot is made, by pouring melted lead into an iron box, perforated with small holes in the bottom, through which it runs into a vessel of water; but as it forms itself into a kind of drops, in the shape of pears, a small quantity of orpigment, or of white arsenic, is mixed with the metal, by which means it becomes harder, and assumes the form of more perfect spheres. Those which are not sufficiently so, are separated from the rest, by making the whole run straight down in an inclined plain, and those which are irregular tumble off at the sides. After this the shot is sorted, by passing through sieves of different sizes.

11. Lead exposed to the air tarnishes so much more easily, as the air is more humid: it contracts a white rust, which the water gradually carries off. Water in fact alters lead, particularly if charged with saline matters. Caustic alkaline lixivia, boiled on vessels of lead, dissolve a small portion of it, and corrode a considerable quantity of the same. Even the sides of the vessels, for carrying water, are covered with a whitish crust, which has been examined, and is found to be a true calx of this metal.

12. It has been observed, that plants do not thrive so well in leaden, as in earthen vessels.

13. All the phænomena of the calcination of lead, and of its reduction to the metallic state, evidently shew that it has the smallest adhesion to phlogiston, as appears by the simple action of fire, which separates both, whilst their attraction is equally as quick in its reduction to the metallic state. A common red wafer, which owes its colour to red lead, by being burned in the flame of a candle, immediately exhibits pure globules or little drops of the reduced metal. The curious experiments made lately at Paris, by Doctor Luzuriaga, pensioner of the Court of Spain, gives another evident proof of the readiness with which lead parts with its phlogiston.

phlogiston. He put 4 ounces of lead shot, wetted with water, into a pint bottle filled with *atmospheric air*, and closed with stopple; he shaked it various times; a black powder was produced, which soon turned white; at the end of 24 hours, on opening it, inverted in a bason of water, the air had lost the fifth part of its bulk, and was quite *phlogisticated*. The same happened with *dephlogisticated air*; but its bulk was still much more reduced; the contrary happened, however, when the experiment was made with *inflammable air*, which, if it is not *phlogiston* itself, is at least greatly loaded with it. *Journ. de Physique* for Oct. 1784, p. 256.

14. The effects of lead on the human body, if internally taken, are very dangerous. Those who are long exposed to its vapours when melted, even those who grind its *calces*, as *minium*, *ceruse*, and *litharge*, for painters, are subject to violent gripes, and constipations of the bowels, contractions of the limbs, and other disorders. Culinary vessels, lined with a mixture of tin and lead, which is the usual tinning, are apt to communicate to acid foods, sour broths, sauces, syrups, and other alimentary preparations, with juice of lemons, or other vegetable acids, very pernicious qualities, chiefly if they are suffered to stand long on the vessels; and the more so, if the persons are of an irritable habit by their bodily constitution. At any rate this metal, when received into the stomach and intestines, even of the most robust persons, occasions violent colics, frequently accompanied with vomiting of green bile, and remarked for the flattening of the belly and depression of the navel. The antimonial emetics and purgatives are used in these cases with success. Navier recommends the different *livers of sulphur*, in cases of persons poisoned with *lead*, as well as with *arsenic*, and *corrosive sublimate*. It is particularly successfull in the palsy and tremors, which generally attend those who have laboured under the *Collica Pictonum*. The *Editor*, from *Newman*, *Watson*, and *Fourcroy*.

15. In Holland, and perhaps in other places, it has been customary to correct the most offensive expressed oils, as that of *rape-seed*, and rancid oils of *almonds*, or of *olive*, by impregnating them with lead, which mixture renders them very pernicious to health, if taken internally. This dangerous abuse may be discovered, if suspected, by mixing a little of that oil with a solution of *orpigment* made in *lime-*

SECT. 318. (192.)

Copper [a], *Cuprum*, *Æs*, *Venus*.

General Properties of this Metal.

This metal is,

a. Of a red colour.

b. The ſpecific gravity of the Japan copper is 9000, and of the Swediſh 8784 or 8843 to 1000.

It

water; for, on ſhaking them together, and ſuffering them to reſt, the oil, if it has any ſaturnine tint, will appear of an orange-red colour; but if pure, it will appear of a pale yellowiſh one.

16. The ſame abuſe has been alſo practiſed with *acid-wines*, which diſſolve ſo much lead, or ſugar of lead, as to acquire a ſweet taſte; but it then becomes a ſlow poiſon to thoſe who drink it. This may, however, be diſcovered in a ſimilar manner; and it is upon the ſame principle that the *liquor probatorius* is made, to aſcertain the fact. This *liquor* is nothing elſe than a ſolution of *orpigment*, or of *liver* of *ſulphur* in *lime-water*. If a few drops of this ſolution be put in a glaſs of the ſuſpected liquor, it will exhibit a precipitation like a cloud of a dark colour. *The Editor from* Fourcroy, Newman, &c.

See the Notes *to p.* 589, *on the pretended power of* fumes of lead *to reduce* quickſilver *into a fixt metal, like* ſilver.

And the note *to p.* 592, *on the imaginary exiſtence of* mercury *in the metallic ſubſtance of* lead.

[*a*] 1. Copper is an imperfect metal, of a peculiar reddiſh-brown colour, and brilliant enough; but it is ſubject to tarniſh: it has a diſagreeable ſmell, perceptible upon friction,

c. It is confiderably foft and tough.

d. The calx of copper being diffolved by acids becomes green, and by alcalies blue.

e. It is eafily calcined in the fire into a blackifh blue fubftance, which, when rubbed to a fine powder, is red; when melted together with glafs, it tinges it firft reddifh brown, and afterwards of a tranfparent green or fea-green colour.

It

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tion, or on being heated; its tafte is ftyptic and naufeous, lefs fenfible, however, than that of iron.

2. It is of a very confiderable hardnefs, tenacity, ductility, and maleabillity; and its elafticity is greater than that of any metal, except fteel.

From this laft property, maffes of this metal emit a loud and lafting found when ftruck, and this more efpecially when of a proper figure; *viz.* if it be fuch that the metal may vibrate in the fimpleft manner poffible. Thus if it be caft into the hollow form of a bell, without any cracks or imperfections, an uniform tone will be produced by it; or at leaft the tones produced by the ftroke will confift of one predominant tone, and of others that have a mufical agreement with it.

3. It has fo vaft a tenacity, that a wire of a tenth of an inch in diameter, is capable of fupporting 299,5 pounds weight, before it breaks. Copper may be drawn into very fine wire, and beaten into extremely thin plates, The German artifts, chiefly thofe of Nurenberg and Aufburg, are faid to poffefs the beft method for giving to thefe thin plates of copper, a fine yellow colour like that of gold, by fimply expofing them to the fumes or vapours of zinc, without any real mixture of it with the metal. Thefe plates are cut into proper fizes; then are beaten as thin as leaf of gold; and put likewife into books of paper, which are fold all over Europe, in large quantities, and at a very low price, for the vulgar kinds of gilding.

The

f. It dissolves in all the acids; viz. The acids of vitriol, sea-salt, nitre, and the vegetable; and likewise in all alcaline solutions. That it becomes rusty, and tarnishes in the air (a consequence of a solution having preceeded) depends very much on some vitriolic acid which is left in the copper in the refining.

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4. The parings, or shreds of these very thin leaves of yellow copper, being well ground on a marble plate, are reduced to a powder similar to gold, which serves to cover, by means of some gum-water, or other adhesive fluid, the surface of various mouldings or other pieces of curious workmanship, giving them the appearance of real bronze, and even of fine gold, at a very trifling expence; because the gold-colour of this metalllic powder may be easily raised and improved, by stirring it on a wide earthen bason, over a slow fire.

5. In some of its states, copper is as difficultly extended under the hammer as iron; but proves softer to the file; and never can be made hard enough to strike a spark with flint or other stones, from whence proceeds the use that is made of this metal for *chisels*, *hammers*, *hoops*, &c. in the gun-powder works.

6. When this metal is broken, by often bending it backwards and forwards, it appears internally, of a dull red colour without any brightness, and of a fine granulated texture; not ill resembling, as Cramer observes, some kinds of earthen-ware.

7. Copper continues malleable in a red heat, and in this state extends much more easily than when cold; but it wants that valuable quality of iron, of cohering together, so as to weld, or join together two pieces of it into one, though equally heated.

8. At a degree of heat far below ignition, the surface of a piece of polished copper becomes covered with various ranges of prismatic colours, the red of each order being nearest to the end, which has been most heated.

refining. This metal is more easily dissolved when in form of a calx than in a metallic state, especially by the acids of vitriol and sea-salt, and the vegetable acid.

g. Vitriol of copper is of a deep blue colour; but the vegetable acid produces with copper a green salt, which is called *verdigrise*. It

This last effect, proceeds from the begining of the calcination on the outer surface, the calx being thicker where the heat has been greater, and decreasing thinner and thinner towards the cold part. This explanation coincides with the appearance of that succession of coloured rays formed round the point of contact, between a convex and a plane surface of transparent glass; where the red colour is seen, in each set, towards the thicker angular space that stands between them.

9. This metal reduced into a fine powder, or copper-filings, if thrown across the flame, give *blue* and *green* colours. On account of this property, they are used in fire-works.

10. When the melted copper produces a flame tinged of a *green*, *blueish*, or *rainbow-colours*, it is a mark that the metal burns, and begins to scorify. The heat continuing to increase, the calcination proceeds more rapidly; and powdery scales are formed on its surface, which may be easily rubbed off. This powdery scoria, or calx, cannot be reduced in the greatest heat of common furnaces; but on being exposed to the focus of a good burning lens, the solar rays melt it into a *deep red*, and almost *opake glass*.

11. Copper melts in a strong white heat, rather less than what is required to melt gold or silver; as may be seen in the table at page 230; although various metallurgists say, that this melting heat is superior to that required for fusing these two noble metals.

When melted, if afterwards it is left to cool very slowly, it forms itself into pyramidal crystals, which are sometimes solid, *h.* It may be precipitated from its solutions in a metallic state; and this is the origin of the precipitated copper of the mines, called Ziment copper. *See Sect.* 322.

k. It is not easily amalgamated with quicksilver; but requires for this purpose a very strong

solid, and sometimes composed of smaller ones, adhering sideways to one another.

12. When copper is in a liquid state, it is remarkably impatient of moisture. The contact of a little water occasions the metal to explode, throwing itself about with the utmost violence, to the great danger of the by-standers. There is the same danger in melted brass, or bell-metal, or any other mixture, whereof copper makes a part; so that founders of all sorts should be equally cautious in this respect. Cramer recites a melancholy accident of this kind, which happened at the brass-foundery in *Windmill-hill*, near *Moorfields*, *London*, about 20 years before the time he wrote his work; when several people of quality were invited to see the casting of two large-brass-cannon at a time. The heat of the metal of the first-gun, drove so much damp into the mould of the second, which was near it, that as soon as the metal was let in, it blew up with the greatest violence, tearing up the ground some feet deep, breaking down the furnace, untiling the house, killing many of the spectators on the spot with the streams of melted metal, and scalding many others in a most miserable manner. Copper may, nevertheless, be granulated like other metals, by cautiously pouring a very little at a time into water, as will be mentioned in the *note* [e] to *Section* 332.

13. The *vitriolic acid* does not act on copper, unless concentrated and boiling: during this solution a great quantity of sulphureous gas flies off; afterwards a brown thickish matter is found, which contains the calx of the metal, partly combined with the acid. By solution and filtration, a blue solution is obtained, which being evaporated to a certain degree, produces, after cooling, long rhombodial crystals, of a

ſtrong trituration, or the admixture of the acid of nitre.

k. It becomes yellow when mixed with zink, which has a ſtrong attraction to it, and makes braſs, pinchbeck, &c. *See Sect.* 332 *Note* [*e*].

It

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a beautiful *blue* colour, called *vitriol of copper*; but if this ſolution be merely expoſed a long time to the air, it affords cryſtals, and a *green calx* is precipitated, a colour which all calces of this metal aſſume, when dried by the air.

14. *Blue vitriol*, however, is ſeldom formed by diſſolving the metal directly in the vitriolic acid. That ſold in the ſhops is moſtly obtained from *copper pyrites*. It may alſo be made by ſtratifying copper-plates with ſulphur, and cementing them together for ſome time; becauſe the vitriolic acid of the ſulphur, being diſengaged, attacks and corrodes the metal, forming a metallic ſalt, which, by affuſion of water, yields perfect cryſtals of *blue vitriol*. This ſalt has a very ſtrong ſtyptic taſte, approaching to cauſticity. It fuſes in the fire, loſes its water of cryſtallization, and becomes of a bluiſh-white colour: it requires a much ſtronger heat to ſeparate the vitriolic acid, which adheres more ſtrongly to copper in this ſalt, than to iron in the *green vitriol*.

15. The *nitrous acid*, on the contrary, diſſolves copper, when cold, with great rapidity; and a great quantity of ſmoking air, or gas, flies off, which, on being received in a pneumatic apparatus, and mixed in a glaſs-tube, with atmoſpheric air, ſhews its good or bad quality for the reſpiration of living animals, accordingly as the common bulk is more or leſs diminiſhed. This is one of the moſt important diſcoveries made by the great philoſopher Dr. Prieſtley. Various inſtruments known by the name of *Eudiometers*, have been ſince invented for making theſe experiments with eaſe and ſatisfaction, if properly managed. The more the bulk of the two airs is diminiſhed, the better the atmoſpheric air is for animal reſpiration; on the contrary, the worſt air

is

l. It is easily dissolved by the glass of lead, which is coloured green by it.

m. When this metal is exposed to the fire, it gives a green colour to the flame in the moment it begins to melt, and continues to do so afterwards, without losing any thing considerable of its weight.

It

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is that, which diminishes the least after its being mixed with the *nitrous air*.

16. This nitrous solution of copper is of a greenish-blue, although Fourcroy calls it a *deeper* blue than that by the vitriolic acid. If evaporated with precaution, it crystallizes by cooling; and produces elongated parallelograms; if the evaporation be quickly performed, the prisms are hexaedral, and resemble bundles of diverging needles; but by a strong and quick evaporation only, an irregular mass is produced. This salt has a caustic taste, and is applied to corrode excrescences on the skin: it detonates, though not strongly, over burning coals. When it is dry, if it be placed in a heat not much greater than the hand can bear, it takes fire. A small quantity of this salt, being put in a piece of tin-foil, wetted with a few drops of water, and instantly wraped up, the two ends being folded close, in a few seconds produces a great heat, emits strong nitrous vapours: and a deflagration takes place, bursting with a crackling noise, and throwing out sparkles of fire, after which a grey calx remains behind, as has been already described in the note N° 8. to page 639.

17. The *marine acid* dissolves copper only when concentrated and boiling; it assumes a deep green, almost approaching to a *brown* colour. This combination produces a mass very soluble in water; this last becomes of a fine *green* colour, which distinguishes it from the two preceeding solutions by the vitriolic and nitrous acid. This marine salt of copper is of an agreeable grass-green colour, is caustic, and of a very astringent taste. The air, or gas, that is produced by the

n. It requires a ſtrong degree of heat before it melts, though leſs than iron.

SECT. 319. (193.)

Native Copper, *Cuprum Nativum.*

Copper is found in the earth,

A. Native, or in a metallic ſtate; Virgin or native copper, *Cuprum nativum.*

1. Solid, *Solidum,* is found in the iron mine of Heſslekulla, in the province of Nerike, and at Sunnerſkog, in the province of Smoland; alſo in the Ruſſian Carelia, and in other foreign places [*a*].

Friable

action of marine acid on copper, has not been well examined, as Fourcroy remarks; it ſeems, however, to be of the inflammable kind. Vegetable acids, alkalies, and oily or fat ſubſtances, act alſo on copper. The dangerous conſequences of theſe ſolutions will be mentioned in Sect. 332.

18. Copper grows *black* or *brown* by long expoſure to the air, which acts upon it the more eaſily when it is moiſt or altered; and forms upon its ſurface a *green* ruſt or calx, which ſeems of a ſaline nature; ſince it has taſte, and is diſſolved by water. But this ruſt only attacks the ſurface of the metal, and even ſerves to its preſervation, as we may learn from the antient medals and ſtatues, which are well preſerved under this coat or ruſt which covers them. The antiquaries call this *cruſt* by the name of *patine*; and value it greatly, as a mark of the great antiquity of the pieces covered therewith. *The Editor from* Kirwan, Nicholſon, Fourcroy, Newmann, &c. *See the* notes *to* Sect. 332. *concerning the* uſes *of copper, and its* poiſonous *qualities, when taken internally.*

[*a*] 1. Native copper, *viz.* copper in a more or leſs malleable ſtate, and either of its own peculiar, or of a grey

or

2. Friable in form of small, and somewhat coherent grains, *Cuprum nativum particulis conglomeratis distinctis*. Precipitated or Ziment Copper. It is found at Riddarshyttan in Westmanland, at Fahlun in Dalarne, and in Hungary.

It has been observed, that both copper and the vitreous silver ores after settling from water, are loose, or in grains; but that they in time grow

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or blackish colour, has been found either in *grains*, or in large shapeless *solid lumps*, or in a *foliated*, *capillary*, *arborescent* form; or *crystallized* in quadrangular pyramides, on clay, shistus, quartz, fluors, zeolytes, &c. in *Siberia*, *Sweden*, *Germany*, *Hungary*, *Transylvania*, *&c.*

2. It undoubtedly has sometimes been produced from precipitation by *iron*, from water in which it was held in solution; and this is the purest sort. But in many cases it could not have been produced in that manner; and then this sort is never very pure, but mixed either with *gold*, *silver*, *iron*, or with *sulphur*: This last combination forms what is called *black copper*. Kirwan.

3. Native copper is found in very considerable quantities at *Cape Lizard* in Cornwall: it is formed into threads or branches, and veins of some thickness, contained in blackish serpentine mixed with brownish red, and covered externally with a greenish nephrites, partly adherent to it, and partly loose. In the same rocks also, native copper has been found in large lumps.

4. But a more considerable quantity of *native copper* is found at *Huel-virgin* in the same province; it shoots into various branches, and in various directions; they seem to be formed of small rhomboidal crystals, interspersed with quartz, of which the impressions are to be seen in the copper itself; from whence it might be concluded the prior existence of the quartz before the formation of the metal. Some of these lumps of native copper have been found in this spot that

grow solid and ductile: whence the dispute about the distinction between *native* and *precipitated* copper may cease, the rather as *native* copper will scarcely be found in other places, and in any other kinds of stones, than those through which the ziment or vitriolic waters have circulated; although the fissures through which it has run, may afterwards be filled with a stony substance.

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weighed from 20 to 30 pounds; and only in the month of March 1785, there were extracted from this mine no less than 1400 tons, *viz.* 2800000 pounds weight of rich copper ore.

5. At the place called *Carrarach*, which is contiguous to *Huel-virgin*, and which is not a less rich mine, some crystallized native copper was found, with the transparent vitreous copper ore, of a ruby colour, crystallized in octahedrons; but this fine red-crystallized vitreous copper ore begins to be very scarce there.

6. Near the copper vein at Carrarach, is found also a compact native copper, of a spherical form, in lumps; the copper, either is still in its metallic form; or is beginning to be transformed into red copper-glass, imbedded in decayed granite.

7. Native copper, of a tender and moss-like form, united to vitreous ruby copper-ore, crystalized in rhombs, is found in the clefts of the mountains composed of killas, near Poldry. *The Editor from* M. H. Klaproth's *Observations on ores of Cornwall.*

8. An indurated iron-clay has lately been found under the surface of the sea, in the Faroe Isles, in which there is scattered a zeolite, with *native copper*. Brunnich.

SECT.

SECT. 320. (194.)

Calciform Ores of Copper.

B. In form of a calx, *Minera cupri calciformis.*
1. Pure, *Minera cupri calciformis pura.*
a. Loose or friable, *Ochra veneris.*
1. Blue, *Cæruleum montanum* [a].

Is

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[a] 1. This, and the two following ores of copper, are mineralized by the aerial acid; they are soluble in acids, and blacken in a moderate heat. The first is called *mountain-blue*, though some call it by the name of *Chrysocolla*, and the Hungarians give it the name of *lapis lazuli*; but this last is a true zeolyte, whose blue colour proceeds from iron, as has been observed already in Sect. 139, and p. 248.

2. The *Mountain Blue* frequently appears in a *loose form*, but sometimes it is *indurated*, and even crystallized: it is then mixed with quartz, 100 parts of it contain about 69 of *copper*, 29 of *aerial acid*, and 2 of *water*. Mr. Morveau has shewn that the calces of copper are determined rather to a *blue*, than to a *green colour*, by a greater proportion of phlogiston. The *Editor from* Kirwan.

3. The *azure* copper ore is also met with on quartz at the mines of *Huel-virgin*, and at *Carrarach* in Cornwall, according to *Klaproth's observations.*

4. Another *Cæruleum montanum*, less pure than the above, will be mentioned in Sect. 322.

We may observe in general, that the copper ores, after roasting, communicate a *blue colour* to volatil aklali, by digestion. Before roasting, it is possible that the mixture of a portion of arsenic, or even sulphur, in a sufficient quantity, may prevent this effect. *Kirwan.*

1. This

Is very ſeldom found perfectly free from a calcareous matter.

2. Green, *Viride montanum.*

Both theſe colours depend on menſtrua, which are often edulcorated or waſhed away [b].

3. Red [c]. This is an efflorescence of the glaſs copper ore. It is found in the province

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[b] 1. This ore is commonly called *Malachite* when in a ſolid form. It has the appearance of green jaſper; but is not ſo hard, ſince it does not ſtrike fire with ſteel. It is either of a radiated or uniform texture, generally of an oval form, and of the ſize of an egg; but ſometimes it is formed of capillary filaments, like ſattin, and ſhews a kind of concentric ſtripes, or ſhreds of paler colours, when cut and poliſhed; its external appearance is like a thick ſhell, with various protuberances of a mamillary form. The ſilky-green copper-ore of this kind from China, in the form of ſolid bundles, is the pureſt. It is found alſo in great quantity on the Voſges, mountains ſo called in Lorraine, and in the mines of the Hartz in Saxony.

2. According to Kirwan, the pureſt malachite contains 75 parts of *copper*, and 25 of *aerial acid.* Its ſpecific gravity, according to *Muſſchenbroeck*, is from 3,500 to 3,994. It is ſometimes mixed with calcareous earth and gypſum; and is found in *Norway* and *Siberia*, &c. Kirwan.

3. Compact *green copper* ore, like malachite, mixed with grey copper-ore; and likewiſe *green-velvet-like* copper, in the form of bunches, is found at Huel-Virgin, in Cornwall. At Carrarach, in the ſame county, is found alſo an amorphous green copper-ore, on a decayed granit; and at St. Menan, the ſame is found ſtratified betwixt quartz, and covered with a browniſh iron. *The Editor from* M. H. Klaproth.

[c] 1. This red-ore is the *Minera hepatica*, or the *Leberertz* of the Germans: it is found ſometimes in a looſe form, and is then called *copper-ochre*: but generally it is moderately hard, yet brittle: ſometimes is cryſtallized and tranſparent,

of Dal, and at Oſtanberg, in the province of Dalarne.

SECT. 321. (195.)

Red Copper-ore.

b. Indurated, *Indurata.*

a. Red, *Minera cupri calciformis pura & indurata, colore rubro.*

This is ſometimes as red as ſealing-wax, and ſometimes more of a liver-brown colour. It is found in Sandbacken, or Norberg in Weſtmanland, at Ordal in Norway, in Siberia and in Suabia in Germany.

This ore is always found together with native copper, which ſeems to have loſt its phlogiſton by efflorescence, and to be changed into this form. It is likewiſe found with the ſulphurated copper, called *Glaſs copper ore.*

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either of a capillary appearance, or in *cubes*, *priſms*, or *pyramids*. It is found in *England*, *Scotland*, *Germany*, &c.

2. This ore contains 73 parts of *copper*, 26 of *aerial-acid*, and 1 of water; and effervesces with acids.

3. The *brown*, or *hepatic* ore of this kind, contains a variable proportion of *iron*, or *pyrites*, and ſometimes *ſulphurated iron*: and affords from 20 to 50 *per cent.* of copper.

4. It is ſometimes irideſcent in its colour, like the *cat's eye*, or the pſeudopalus of Sect. 95. *The Editor chiefly from* Kirwan.

SECT. 322. (196.)

Calciform Copper-ore, impure.

2. Mixed, *Minera cupri calciformis impura*
a. Loose or friable, *Ochra veneris friabilis impura.*
1. Mixed with a calcareous substance, *Ochra veneris terrâ calcareâ mixta* [a]. *Cæruleum montanum.* In this state copper-blue is mostly found. It effervesces during the solution in aqua fortis. *See Sect.* 40. (34.)
2. Mixed with iron. Black. It is the decomposition of the Fahlun copper ore. *Sect.* 198. *a.* of the Author [b].

Indurated,

[a] In Saalfeld they find also a sort of *green*, somewhat indurated calcareous substance, containing copper; this, when broken, looks fat, and somewhat shining; but upon the whole, it resembles a jasper. It is there very wrongly called a *Green Copper Glass-ore.* They make good copper of it. With a phlogistic substance, without being ustulated, it forms a fit mass for bells, or a kind of bell-metal. *Brunnich.*

[b] By the *fahlun copper ore*, is meant the copper ore of a *fallow* or *fallow* colour. *Lewis.*

In some parts, among the native copper-ores from Poldory and Huel-virgin, is found a calciform copper-ore, sometimes in a loose form, covering them like sand; and some times this forms a compact structure, which adheres strongly to them. The former *b.* Indurated, *Minera cupri calciformis impura indurata.*

1. Mixed with gypſum, or plaſter. Green. Is found at Ordal in Norway, and there called Malachites.
2. Mixed with quartz. Red. From Sunnerſkog, in the province of Smoland. *Sect* 91. (53.) *B.*
3. Mixed with lime. Blue. This is the *lapis armenus*, according to the accounts given of it by Authors [*c*].

S E C T. 323. (Additional.)

The Cupreous Stones.

Analogous to the calciform copper ores, are the *lapis Armenus*, of which was already ſpoken in Sect. 41. p. 61: and in the note [*c*] to the preceeding Section 322. This is very different from the *lapis lazuli*, deſcribed in

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former kind is generally black; and the latter is of a browniſh red, often approaching to the metallic ſplendor of copper. *The Editor from* M. H. Klaproth's *Obſervations on the Foſſils of Cornwall.*

[*c*] The *Lapis Armenus* is a blue ſtone, which does not admit of a poliſh, and conſiſts of calcareous earth, or gypſum, penetrated with the blue calx of copper; hence it ſometimes efferveſces with acids, and ſometimes not; but never gives fire with ſteel. It loſes its colour, when well heated in the fire. *See Sect.* 41 (35) *pag.* 60. The Editor *from* Kirwan.

Sect. 139. p. 247. among the zeolytes; ſince this laſt contains no copper, as may be ſeen in the *notes* to the ſame Section.

The other cupreous ſtone is the *Turquoiſe*; and ſeems to be the tooth of an animal, penetrated with the blue calx of copper. It loſes its colour when over-heated. It is opake, of a lamellar texture, and ſuſceptible of a fine poliſh.

Its ſpecific gravity is from 2,5 to 2,908. Some are of a deep blue, ſome of a whitiſh-blue, but become of a deeper when heated. Theſe ſtones are found in *Perſia* and in *Turkey*, from whence they received their name. But they are alſo found in Lower Languedoc, in France, near the village Simore, where theſe ſtones, when dug out from the mine, reſemble different *bones*, *teeth*, &c. of various ſizes; and are either *whitiſh*, *grey*, or *yellowiſh*. They receive the blue colour, on being ſlowly heated to a high degree; but if the fire be long continued afterwards, the colour is irrecoverably loſt.

Jewellers divide this kind of ſtones, or rather bony ſubſtances, according to their fanciful method into *oriental* and *occidental* turquoiſes; ranging the hardeſt and the fineſt coloured under the firſt epithet, and the ſofteſt, or of an inferior colour, under the *ſecond* denomination. But although experience ſhows the fallacy of ſuch diſtinctions in a great many inſtances, the old cuſtom nevertheleſs continues to prevail.

According

According to Kirwan the blue coppery tincture of the turquoises may be extracted from them by distilled vinegar: and Reaumur asserts, that nitrous acid will not dissolve the Persian turquoises, though it will those of France; which, if true, indicates a real difference between them. *The Editor from* Kirwan, Neumann, Bomare, &c.

SECT. 324. (197.)

Copper mineralized by Sulphur.

C. Dissolved and mineralised, *Cuprum mineralisatum.*

1. With sulphur alone, *Cuprum sulphure mineralisatum.* Grey copper ore. It is improperly called *Glass copper ore.*

   a. Solid, without any certain texture, *Minera cupri sulphurata solida, texturâ indeterminatâ.* This is very soft, so that it can be cut with a knife, almost as easily as black lead [a].

Fine

[a] 1. According to Kirwan, this is the true *vitreous*, or *glass-copper ore*, the *kupfer glass ertz* of the Germans.

The colour of this ore is *red*, *brown*, *blue*, or *violet*. It is generally so soft, as to be cut with a knife; and as to its form, it is sometimes crystallized in regular forms, and sometimes it is amorphous.

This ore is much more fusible than pure copper. Its specific gravity is from 4,810 to 5,338, and is found in the mines *b.* Fine cubical, *Minera cupri sulphurata tessulis constans minoribus.*

Both these varieties are found at Sunnerskog, in Smoland; where the last is sometimes found decomposed, or weathered, and changed into a deep *mountain-blue.* See Sect. 320. (194.)

SECT.

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mines of other copper-ores, and in lime-stone, spar, quartz, mica, and clay.

It is the richest of all copper-ores; and affords from 80 to 90 *per cent.* of copper, and 10 or 12 of sulphur. According to Bergman, it generally contains some alloy of iron. The poorest red ores of this sort, are those which contain most iron. *The Editor chiefly from* Kirwan.

2. There is a great variety of sulphurated copper-ores in the mines of Cornwall. A whitish grey copper-ore, crystallized in small triangular and quandrangular pyramids, with truncated points, is found along with the solid copper ore at Poldice and Dolcoth. But the richest are the *solid grey* ones from Treseavean, Retallack, Cook-Kitchen, Carrarach, Well-Virgin, and Redruth. Some of these may be cut with a knife, like the soft vitreous silver-ore, particularly those from Treseavean.

3. Yellow copper-ores of the kind are found at Poldice, Hallamanning, and Dol-coth. The most remarkable of them is the stalactitical ore, of an hemispherical form, called *Run-yellow copper*, found in the mine near Dolcoth, which is 160 yards deep, though elevated more than 60 yards above the level of the sea. This ore is often variegated with the colours of blue steel, or red copper.

4. A compact red vitreous copper-ore, covered with mountain-green, or green copper, and with calciform copper of a vermillion-red colour, is found in crystallized quartz, mixed with tender green mica, in the mine at Kastle Adit.

5. A new kind of an *olive green coloured* copper-ore, which is arsenical, and is crystallized into tender spiculæ, of about

three

SECT. 325. (198.)

Pyritous Copper-ores.

2. With ſulphurated iron, *Minera cupri pyritacea.* Yellow copper ore. Marcaſitical copper ore, *Pyrites cupri.*

This is various both in regard to colour, and the different proportion of each of the contained metals; for inſtance;

a. Blackiſh grey, inclining a little to yellow, *Pyrites cupri griſeus.* The Fahl cupfer ertz *of the Germans.*

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three lines long, ſtanding ſtraight up, either ſingle, or faſciculated and radiated, was found alſo on the granitical mountain at Carrarach. When tried by the blow-pipe, theſe cryſtals deflagrate with an arſenical ſmoke, and afterwards fuſe, forming a button of a grey colour, which on being melted again with borax, ſoon produces a button of a very pure copper.

Beſides this new arſenical ore, M. H. Klaproth, from whoſe *Mineralogical Obſervations on the mines of Cornwall* theſe two articles are taken, mentions another kind of arſenical copper-cryſtals, which are very ſmall, and aggregated in the form of green cubes, with ſmooth and ſhining ſurfaces, upon grey copper ore, in a maſs of cryſtallized compact quartz, with various cavities in itſelf. Theſe might be eaſily taken for ſmall cubes of fluor; but their conſtituent parts are really nothing elſe but copper and arſenic. *The Editor from* Klaproth's *Obſervations* on the *Mines of Cornwall.*

When decayed or weathered, it is of a black colour; is the richest of all the varieties of this kind of copper ore, yielding between 50 and 60 per cent. and is found in Spain and Germany.

b. Reddish yellow, or liver brown, with a blue coat on the surface, *Minera cupri lazurea* [*a*].

This ore yields between 40 and 50 per cent. of copper, and is commonly said to be blue, though it is as red, when fresh broke, as a rich copper regulus.

c. Yellowish green, *Pyrites cupri flavo viridescens* [*b*].

This is the most common in the north part of Europe; and is, in regard to its texture, found

1. Solid, and of a shining texture, from Ostanberg, in the province of Dalarne.

[*a*] This ore is mineralized by sulphur, with a considerable portion of iron, and is called *kupfer lazur*, and *kupfer malm*, by the Germans.

Its colour consists in various shades of *blue* and of *reddish blue*.

It is of an hard consistence, but brittle.

Contains from 40 to 60 *per cent.* of copper; from 20 to 30 of iron; and the remainder is sulphur.

The poorer it is in iron, the richer in copper.

This has been confounded by many with the indurated *Mountain blue* of Sect. 322. *The Editor chiefly from* Kirwan.

[*b*] This ore presents fragments in its fracture; its specific gravity is 4,160; contains more sulphur; and from 15 to 30 *per. cent.* of copper. *Kirwan.*

2. Steel-

2. Steel-grained, dull in the fracture, from the same place, and Falun in Dalarne.
3. Coarse grained, is of an uneven and shining texture. It occurs in most of the Swedish and Norwegian copper mines.
4. Crystallised marcasitical copper ore.
a. Of long octaedral crystals [*c*].

This is found at Hevasswik, in the province of Dal, and in Lovisagrufva, in Westmanland; notwithstanding its existence is denied by Henckel, and his followers.

d. Pale yellow, *Pyrites cupri pallidè flavus* [*d*].

This cannot be described but as a sulphur pyrites, though an experienced eye will easily discover some difference between them. It is found at Tunaberg, in the province of Sodermanland, and yields 22 per cent. of copper.

e. Liver-coloured.

This is found at Falun, in Dalarne, where it contains copper; though at most other places where it occurs it does not contain any copper, but is only a martial marcasite.

[*c*] This crystallized sort is the poorest in copper, it contains only from 4 to 8 *per cent.* the remainder is chiefly iron: it is generally reddish, and is in fact a martial pyrites, with a small portion of copper. *Kirwan.*

[*d*] The pure yellow contains most copper; namely from 20 to 30 *per cent.* its texture is foliated. These pyritous ores always contain some *argillaceous* earth, and a little of the *siliceous.* Kirwan.

SECT. 326. (Additional.)

Pyritous Copper, with Silver and Arfenic.

With fulphurated filver, arfenic, and fome iron. *Cuprum argento fulphurato, arfenico et ferro mineralifatum.* Fallow copper-ore.

In Hungary it is called *Black Copper-ore.*

It contains only a few ounces of *filver.*

This ore is found in Hungary and Germany [a]. Thefe ores yield a brittle copper regulus.

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[a] The following natural mixtures of copper-ores, with other metals, have been already mentioned in the preceding fections, *viz.*

Copper with gold pyrites. *See Sect.* 263. *p.* 527. Note [*d*] N°. 6.
with gold and filver, &c. *See Sect.* 265. *p.* 544. No. 2 and 3.
with filver and iron, &c. *See Sect.* 272. *p.* 554.
with filver and antimony, &c. *See Sect.* 276. *p.* 559.
with mercury, &c. *See Sect.* 294. *p.* 601. The Editor.

SECT. 327. (199.)

Pyritous Copper, with Arsenic, or White Copper-ore.

3. With sulphurated arsenic and iron, *Cuprum ferro et arsenico sulphurato mineralisatum.* White copper-ore [a].

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[a] 1. This copper-ore, is called *arsenical*, or *grey copper ore*. *Kupfer Fahlertz*, or *Weiss Kupfererts*, by the Germans.

It is of a *white*, *grey*, or *brown* colour; is moderately hard and very brittle.

Sometimes it is crystallized, but often of an indeterminate figure. It is of a very difficult fusion, and pretty heavy.

It contains from 35 to 60 *per cent.* of copper. The *brown* is the richest in copper; the *white* or *grey* contains most arsenic.

It frequently contains silver. If it exceeds 1 or 2 *per cent.* it is then called *grey silver ore.*

It is found embodied in all sorts of stones, and mixed with other copper-ores, as well as with the ores of all other metals. *Kirwan*, p. 266.

This kind of copper-ore is found also in the copper and tin-mines of St. Ives in Cornwall, according to the account given by Mr. Raspe: and the Chev. Born mentions the same ore found in Hungary. *The Editor.*

N. B. To assay these ores in the dry way, they should first be pulverised and separated, as much as possible, from stony and earthy particles; then roasted, to separate the sulphur and arsenic; then melted with an equal weight of *Mr. Tillet's flux*, which consists of two parts of *pounded glass*, one of calcined *borax*, and $\frac{1}{8}$ of *charcoal*. If the ore be poor, more borax may be added. Black flux is hurtful, as it forms an *hepar*, which holds part of the copper in solution. *Kirwan*, p. 267.

It is said to be found in the Hartz, in Germany, and to resemble an arsenical pyrites; but I have never met with this kind.

However, most of the pyritous copper ores, as well as the sulphur pyrites, contain a little arsenic, though it is in too small a quantity to be worth notice.

SECT. 328. (Additional.)

Pyritous Copper, with Arsenic and Zinc.

According to Mr. Monnet, this ore is found at *Catharineberg* in *Bohemia*.

It is of a brown colour; of a hard, solid, and compact granular texture.

It contains from 18 to 30 *per cent.* of copper [a].

[a] 1. It is analysed in the liquid way, by solution in *nitrous* acid, and precipitation of the copper by iron.

2. The iron and zinc are precipitated by the *Prussian alkali.*

3. The precipitate is calcined and redissolved in nitrous acid, which solution is evaporated to dryness.

4. The iron being thus dephlogisticated, becomes insoluble in nitrous acid.

5. The calx of zinc, on the contrary, is redissolved in that acid, and again precipitated by the *Prussian alkali.*

6. 100 *gr.* of this precipitate, washed and dried, are equivalent to 20 of zinc in its metallic state; and 100 *gr.* of dephlogisticated iron are equivalent to 73,5 of iron in its metallic state. *Kirwan*, p. 268.

SECT. 329. (200.)

4. Dissolved by the vitriolic acid, *Cuprum acido vitrioli solutum: Vitriolum Veneris* [a]. See Sect. 205. (122.2)

SECT.

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[a] 1 In the year 1673, our countryman, Dr. Brown, visited a famous copper-mine at *Hern-grundt*, about seven English mines from Newsol, in the *Upper Hungary*; and he informs us that there he saw two springs, called the *Old*, and *New zim nt*, which turned iron to copper, as it is vulgarly said. But the case is, that the *iron* is dissolved by the *vitriolic acid* of this spring-water, and the *copper* is precipitated, in its metallic form, in the place of the *iron*. It has been the custom in Germany, for some centuries, to collect the copper contained in these waters, by filling with them some pits made purposely for this operation. Old iron is thrown in, and being dissolved by the acid, is suspended in the water, whilst the copper is precipitated: the mud being raked out, is melted afterwards in a furnace, and a very fine copper is produced: from *one hundred* tons of iron, 84, and sometimes 90 tons of fine copper is thus produced.

2. But although this method of obtaining copper has been long practised in Germany, yet it is but of late years, says Bp. Watson (p. 238 of the first volume of his Essays), that any successful attempts of this kind have been made either in *England* or *Ireland*. In this last at least, it was quite owing to an accident. There are the very celebrated copper-mines at *Arklow*, in the county of *Wicklow*, in Ireland; and from these mines, issues a great quantity of water, strongly impregnated with *vitriol* of *copper*. One of the workmen having accidentally left an *iron shovel* in this water, he found it, some weeks after, so incrusted with a coat of copper, that it was thought to be changed into copper.

 3. The

SECT. 330. (Additional.)

Copper mineralised by the Muriatic Acid.

This copper-ore was found in Saxony, and had been generally miſtaken for a *micaceous*

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3. The proprietors of the mines, in purſuance of this hint, made proper pits and receptacles for the water, and have obtained, by means of ſoft iron bars put into them, ſuch quantities of copper, that theſe ſtreams are now of as much conſequence as the mines themſelves. One ton of *iron* produces near two tons of copper mud; and each ton of mud produces, when melted, 16 hundred weight of copper, which ſells for 10 *pounds ſterling* a ton more than the copper which is fluxed from the ore.

4. There is in the Iſle of *Angleſey*, on the coaſt of North-Wales, a mountain called *Paris*, which abounds in copper-ore, the bed of ore being above 40 feet in thickneſs. The leſſees of this mine annually raiſe from 6 to 7 thouſand tons of merchantable ore, and daily employ above 40 furnaces in ſmelting it. This ore contains great quantity of ſulphur, which muſt be ſeparated by roaſting, before it can be fluxed into copper. The phlogiſton, with part of the vitriolic acid, is diſperſed into the air, by the force of the fire; another part of the acid attacks and diſſolves ſuch a quantity of the copper, that the water in which the roaſted ore is waſhed (by means of old iron immerſed in it, according to the German method) produces great quantities of fine copper, ſo that the proprietors have there obtained in one year near one hundred tons of the copper precipitated from this water.

5. If this water was afterwards evaporated, it would yield *green vitriol*, or *vitriolated iron*, at nearly the rate of two *hundred tons* of *vitriol* for *each hundred* ton of *iron* at leaſt: which, at the rate of 3 *pounds* ſterling per ton, might perhaps produce very good profit to the undertakers, if any ſhould ſettle ſuch a manufacture there. *The Editor from* Bp. Watſon.

ſubſtance,

substance, which in fact it greatly resembles.

It has not yet been found in large masses, but only in a superficial form, like a crust over other ores.

It is moderately hard and friable; of a fine *green* colour, and sometimes of a *bluish-green*, crystallised in a cubic form, or with a foliated texture, or in little scales, resembling *green mica*, or *talc*. This ore is easily dissolved by nitrous acid: the solution takes a green colour; and the metal may be precipitated on a polished plate of iron.

If some drops of a *nitrous solution* of *silver* be mixed with it, a white powder of *luna cornea* will be precipitated, which discovers the presence of the *muriatic acid* in this ore.

Dr. Werner, in his German translation of the Mineralogy of our Author, describes this copper-ore: he sent a specimen of it to Professor Bergman, who analysed it, as he informs us in the Sect. 191. of his Sciagraphia, as well as when he speaks of the *minæ cupriferæ* in his *docimasia humida*, p. 431.

Mongez mentions four fine samples of this ore, that were brought from the mines of Johnn Georgenstad; and adds, that a similar kind of copper-ore was sold so late as the year 1784 at Paris, by a person called Dans, as a mere *green mica*. The Editor.

SECT. 331. (part of 200.)

5. *Copper-coal ore* [a].

This copper ore cosists of the calces of this metal mixed with a bituminous earth. See Sect. 258 (161) pag. 501.

See Sect. 258. (161.) p. 501.

SECT. 332. (Additional.)

Observations on Copper.

Copper-ores are found in almost all parts of the world; and are easily distinguished from those of any other metal, by the *blue colour* they give to *volatile alkali*, on being digested with it, after they have been previously *roasted*; otherwise it is possible that the *arsenic*, which they sometimes contain, and even the *sulphur*, if in sufficient quantity, may prevent this effect, when they are in their crude natural state; *viz.* before their being roasted by the action of fire.

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[a] In the Banat of Temeswar, below the green copper-calx, they find a compact, blackish-brown substance, which is there called *pitch-ore*; it contains a considerable quantity of copper, and, when put into the fire, does not burn with a flame. We are still in want of an accurate enquiry into its constituent parts. *Brunnich.*

Copper mixt with black pitchy rock-oil has been found in Cornwall, according to Raspe's account. *The Editor.*

They

They are particularly found in Spain, France, England, Norway, and Tranſylvania. The copper that comes from Japan, according to Neumann, is much ſuperior to any other that is found in Europe.

As to England in particular, no country in the world can boaſt of copper-mines more numerous, nor more productive for a longer period. It ſeems as if this Iſland was grounded on a metallic bottom, of various kinds, which will never be exhauſted by all the labours of mankind for centuries to come [a].

The

[a] Beſides the celebrated copper-mines at *Arklow*, in the County of *Wicklow*, in Ireland, there are no leſs than 17 out of the 48 counties of England, in which copper-mines are found; as mentioned by Dr. Campbell in the 2d vol. p. 44, of his *Political Survey of England*. Theſe are Cardiganſhire, Cheſhire, Cornwall, Cumberland, Derbyſhire, Devonſhire, Lancaſhire, Iſle of Man, Northumberland, Shropſhire, Somerſetſhire, Staffordſhire, Yorkſhire, Wales, Warwickſhire, Weſtmoreland, and North Britain: ſome that are worked at this time give ſuch large products of this metal, that the opening more copper-mines in this iſland would probably affect the copper trade of Europe in a very conſiderable manner. The *Ecton-mine*, in the Eſtate of the Duke of Devonſhire, on the frontiers of Derbyſhire, but properly ſituated in the county of Staffordſhire, produces at leaſt 300 tons of copper *per annum*. That of the mountain called *Paris*, in the Iſland of Angleſey, whoſe *bed of ore* is about 40 feet in thickneſs, produces about 1500 tons of copper in the year: and the copper-mines of Cornwall produce no leſs than 4000 tons in the ſame period. My late and much regreted friend, Mr. Jars, who viſited theſe mines in the year of 1770, found, upon calculation, that the annual produce of theſe mines amounted to 140,000 pounds ſterling: and M. H. Klaproth, in his *obſervations* on the foſſils of Cornwall,

The uses of copper are very numerous, although not thoroughly known to every one. Its great ductility, lightness, strength, and durability, render it of a very extensive usefulness. Blocks, or bars of copper, are reduced into flat sheets of any thickness, by being first heated by the reverberation of the flame, in a low-vaulted furnace, properly constructed for the purpose; and then immediately applied between large rollers of steel, or rather of case-hardened iron, turned by a water-wheel or by the strength of horses; so that the hot metal is there quickly squeezed; and the operation is repeated, bringing the rollers every time nearer to one another, till the metallic sheet acquires the intended thickness.

These copper sheets are very advantageously employed in sheathing the bottoms of men of war, and other sea-vessels, which, by this means, are prevented from being attacked by the sea-worms, and are kept clean from various marine concretions, so as to sail with considerably greater swiftness. Copper sheets are also employed to cover the tops of buildings, instead of slates or earthen tiles, as is used in Sweden; and some Architects have begun to introduce the use of copper covering into Great Britain, which is much lighter, and may be

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wall, just published (in 1787) asserts that this account is not an exagerated one. See No. 3 and 4. of the note to Sect, 330. page 696.

uſed with great advantage, although it muſt be much dearer in the prime coſt [*b*].

Sundry preparations of copper are employed in *painting*, *ſtaining*, and for colouring glaſs and enamels [*c*].

But

[*b*] The following table was publiſhed by Bp. Watſon, in his Eſſay (page 326. of his 4th vol.) by which appears the reſpective weight of each of the 5 materials here mentioned, that is required for covering a ſurface of 42 yards ſquare, *viz.*

Tile	54	hundred weight.
Coarſe ſlate	36	
Lead	27	
Fine ſlate	26	
Copper	4	

[*c*] The ſolution of copper in *aqua fortis* ſtains marble, and other ſtones, of a green colour: when precipitated with *chalk*, or *whiting*, it yields the *green* and the *blue verditer* of the painters.

According to Lewis, a ſolution of the ſame metal, in volatile ſpirits, ſtains ivory and bones: when macerated for ſome time in the liquor, they become of a fine *blue colour*, which, however, tarniſhes by expoſure to the air, and becomes green afterwards.

2. The ſame author prepared elegant *blue glaſſes*, by melting common glaſs, or powdered flint and fixed alkaline ſalt, with blue vitriol, and with an amalgam of copper: fine green ones were made with green verditer, and with blue verditer, as well as with the precipitate of copper, made by fixed alkalies, and with a precipitate by zinc; and a *reddiſh glaſs* was produced by the calx and ſcoria of copper made by fire alone. Even in this vitreous ſtate, it ſeems as if a continuance of fire had the ſame effect in regard to colour, as air has upon copper in other forms: as ſome of the moſt beautiful *blue glaſſes*, by continued fuſion, have changed to a *green colour*. Editor.

3. Verdegris, called *ærugo*, *æs viride*, and *viride æris*, in Latin, is a preparation of copper diſſolved by the vegetable acids;

But the most common use of copper is, to make all sorts of *large stills*, *boilers*, *pots*, *funnels*, and other *various vessels*, employed by *distillers*, *dyers*, *chemists*, and various other ma-

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acids; which act on this metal, dissolving it very slowly, but in considerable quantities. It produces a fine green pigment for painting, both in oil and in water colours, inclining more or less to the *blueish*, according to circumstances. This preparation is made in large quantities in France, particularly about Montpelier, by stratifying clean copper-plates with the husks of the grapes, that remain after the juice has been pressed out, to be turned into wine by a proper fermentation. The husks soon become acid, and corrode the copper-plates: their whole surface is covered, after a certain time, with a very beautiful green crust, which is the *verdegris*. This is nothing else but the copper corroded by the acid of tartar, analogous to the acid of vinegar, which abounds in the wines of Languedoc, and especially in the husks, and stones of grapes, which have a very austere taste. *Verdegris* is a very violent poison.

4. This rust of copper, *viz.* the *verdegris*, is not quite saturated, nor converted into a neutral salt, for it is soluble in water: nor does it crystallize till it is purified by a new solution in distilled vinegar; which is then called, though improperly, *distilled verdegris*, or *flowers of copper*. The cakes of verdegris for this operation must be chosen, neither moist nor unctuous, but dry, compact, and of an uniform texture, of a lively green colour throughout, and as free as possible, from white or black specks, and seeds, or stalks, of the grape. The Dutch, who prepare these crystals in a large quantity, after duly evaporating the solution, set it to shoot, not, as is customary in a cold, but in a warm place, as practised for making *sugar candy*. If these crystals be distilled, the most strong acetous acid is produced, called *Radical vinegar*. But if rectified spirits of wine, or some volatile alkalies, be added to that accetous solution of *verdegris*, small blue crystals will be immediately formed, called *antipileptic crystals of copper*, as Newmann asserts. *The Editor chiefly from* Newman and Lewis.

nufacturers,

nufacturers, who make use of large quantities of hot liquors in their various operations.

Unhappily, the good qualities of copper, and chiefly its ductility and great durability, induced our ancestors to employ it likewise, without due consideration, in all kinds of kitchen vessels, as *boilers*, *porridge-pots*, *kettles*, *sauce-pans*, &c. as they were not aware of the poisonous qualities of this metal, whenever its solution [*d*], even

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[*d*] Copper dissolves not only in *every acid*, but in *alkalies* also, both *fixed* and *volatile*, in *neutral* saline-liquors, and in *oils*: when dissolved, it exhibits fine *blue*, *green*, or *bluish* colours, by which this metal is readily distinguished, however mixed or disguised with other substances. Even pure water, suffered to stand long in copper vessels, extracts so much as to gain a coppery unwholesome taste: and it is remarkable, that fluid liquors become more impregnated with this taste on standing in the cold, than if boiled in the vessel for an equal time. The confectioners prepare acid syrups, even those of orange and lemon-juice, by boiling them in clean copper vessels, without the preparation's receiving the ill taste of the metal; whereas either the juices by themselves, or the syrups made from them, and, what is still worse, the fricassees and other culinary ragouts, if kept cold in clean copper vessels, soon become impregnated with a metallic taste, and acquire the poisonous qualities of the copper.

2. Many have deceived the public, by affirming, that copper vessels, if well tinned in the inside, cannot communicate any poisonous quality to the aliments cooked therein. But, as Gellert observes (pag. 262. of his *Metallurgic Chymistry*), it is by no means sufficient; because there will either some small imperceptible parts remain uncovered with the tinning pewter, or such minute parts will be rubbed off in time by the use and cleaning of the vessel, which being then exposed to the effect of the acting liquors, will produce the same danger, by generating the poisonous verdegris, and dissolving the surface of the copper.

3. Even,

even in the flightest quantity, is once taken internally with any fort of food, or otherwife.

Examples are too frequent of the fatal confequences, from eatables that had received a taint from *copper* veffels, and even from *filver* ones that were largely alloyed with *copper*; whether on account of the acid nature of the food itfelf, which diffolves and corrodes the furface of the metal it touches; or from the veffel having contracted the copperifh-green ruft, called *verdigris*, by laying expofed to the air; a poifon, which is fo readily formed as to baffle the common attention of the fcullions and cooks. I faw at Paris the melancholy fpectacle of a middle aged man, of a ftout bodily complexion, but who laboured

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3. Even if the danger from the copper could fafely be prevented, it is well known, that inftead of employing pure tin, which is not reckoned an unwholefome metal, the mixture generally ufed for tinning copper, or brafs veffels, confifts of 3 parts of lead and 5 of pewter, or at beft of 10 of lead with 16 of tin: and it has been already mentioned (Sect. 304. Note [*b*]. N° 4. and N° 14 of the Note [*a*] to p. 670), that a folution of lead taken internally with our food, or in any other way, is likewife highly pernicious to the life of animals.

4. Inftead of that mixture of tin with lead, zinc alone may be advantageoufly employed to cover the infide of copper or brafs-veffels, as hath been propofed and executed at *Rouen* in France; and perhaps in other manufactures of this kind (as Watfon relates, p. 177 of the 4th vol. of his Effays.) In this cafe the laft objection, from the unwholefomenefs of the lead, would be obviated; but at any rate there remains ftill the danger arifing from the wearing off the zinc in fome parts of the internal furface of the veffels: and confequently no copper, nor brafs-veffels of any fort, fhould ever be employed for culinary purpofes. *The Editor.*

under

under a paralytical disorder, and was deprived of the use both of his limbs and of his intellectual powers, during the last four, or more years of his lingering life: his disorder was produced by eating a fricassée, that remained the preceding night in the stewing copper-pan in which it had been dressed. Application had been made to the best physicians, but they were unable to give him the least relief from so melancholy a situation [e].

Although

[e] 1. Hardly a year passes without hearing of whole families, and numerous guests, that have been destroyed by this kind of poison of copper, or its green-rust, which happened to be dissolved in the soups and stews of their meals; and, if death do not ensue, as in the case mentioned in the text, it is certain at least, that great part of the chronical diseases, palsies, gripings in the bowels, and other habitual complaints, which are supposed to proceed from other causes, do originate from the pernicious old and vulgar custom of employing this poisonous metal in our kitchens, on account of the œconomy supposed to arise from its durability and neat appearance. To my own knowledge, the late Marquis de Courtanvaux, and a few others were taught at last from their own danger not to allow the least vessel of copper or brass, in their kitchens, instead of which they substituted those of *plated*, *forged*, and *cast-iron*, properly tinned in the inside.

2. In consequence of some representations from the *College of health*, the use of *copper* vessels, in the fleets and armies of *Sweden*, was abolished in the year 1754; and *tinned iron* (though it would be still better, if *tinned with zinc*) was ordered to be substituted in their stead, as appears by the Memoires of the Prussian Academy, quoted by Dr. Watson, page 150 of the 4th vol. of his Essays. It is indeed a general opinion, of the best physicians of the age, that many of the violent and obstinate diseases of the European armies, and of the crews of men of war, and other large ships, intirely proceed from the use of greasy and dirty *copper*, or *brass vessels*, employed in the cooking of their messes.

Although copper, when pure [*f*], is extremely valuable on account of its ductility, lightness,

3. Neumann knew a person, who having accidentally swallowed a brass-sleeve button, was seized with the most violent symptoms, and died in misery; no medicines giving any effectual relief; and he also knew various instances of vehement vomitings and convulsions, which proceeded from the *unguentum ægyptiacum*, whose basis is *verdigris*, applied to ulcers in the mouth. *See the first vol. of his works* in 8vo. pag. 98. The Editor.

[*f*] 1. It is well known that the impurity of copper proceeds from the mixture of heterogeneous substances that are alloyed with it, on account of being naturally contained in the copper-ores. Iron and arsenic are the chief of these natural mixtures. The copper ores of *variegated* colours, the *white*-copper ores, and generally those mineralized by sulphur, contain a greater proportion of iron: whilst the *blue* and *green* copper ores commonly produce a purer metal, being free, for the most part, of any considerable ferrugineous mixture.

2. The great aim, therefore, of the metallurgist must be directed to separate these mixtures from the copper, beginning by the proper examination of the ore, and by ascertaining the proportion of sulphur that may be required to scorify the quantity of iron there contained. The ore should always be roasted by a slow fire, in a close furnace, which contributes the best towards scorifying the ferrugineous and heterogeneous mixtures; and the same operation must be repeated after the second and third fusion of the metal, till its grain becomes of an homogeneous fine texture. The mixture of sulphureous pyrites in the fusion of the metal contributes towards obtaining this object; if their quality be chosen, according to the quantity of sulphur wanting.

3. But in the second, third, and following operations, only pure sulphur should be added, to scorify the remainder of the iron, that is still intermixed with the copper. This should be done when the metal is already well fused; covering it immediately with a proper quantity of charcoal, and separating the scoria or dross formed on the surface of the fused metal.

The

lightness, and strength; it is, however, less useful, on many occasions, from the difficulty of forming large masses of work; as it is not an easy matter to cast copper solid, so as to retain all its properties entire. For if the heat be not sufficiently great, the metal proves deficient in toughness when cold; and if the heat be raised too high, or continued for a length of time, the copper blisters on the surface, when cast in the moulds: so that the limits of its fusion are very contracted. And from these circumstances, pure copper is rendered less applicable to several purposes.

We find, however, that the addition of a certain proportion of zinc removes almost all these inconveniencies, and furnishes a mixed metal more fusible than copper, very ductile and tenacious when cold, which does not so readily scorify in a moderate heat, and which is less apt to rust from the action of air and moisture.

Copper is the basis of sundry compound metals for a great number of mechanical and œconomical uses of life, such as *brass* [g], *princes-*

4. The copper extracted from those mines near Newsol, in Upper Hungary, is said to be usually melted 14 times, before it is fit for use. These are the greatest copper-mines in all Hungary. There are, however, other mines, whose copper requires far less fusions to be well purified.

5. The above was the process of Mr. Delius, director of the mines of Bannat near Temeswaré, in Hungary, proposed by him to the Imperial Board of the Austrian Mines. *See Journal de Physique for* July 1780.

[g] 1. *Brass* is frequently made by cementing plates of copper with *calamine*, where the copper imbibes one-fourth

 or

princes-metal, *tombac*, *bell-metal*, *white-copper*, &c.

If the mixture is made of four to six parts of copper, with *one* part of zinc, it is called *Prince's-metal*. If more of the copper is taken, the mixture will be of a deeper *yellow*, and then goes by the name of *Tombac*, or *Tompac*, as Gellert calls it (p. 359. of his *Metallurgic Chemistry*, edit. of 1776.); so that even copper by itself has got that name, says he, when its surface is only stained, by the fumes of zinc, with a gold-yellow colour, which is done, by mixing flowers of zinc with charcoal-dust, throwing this mixture into a heated muffel, and immediately holding a piece of red-hot copper in the fumes rising from the zinc.

Bell-metal is composed of copper and tin. When this last amounts to one-third of the mass, it becomes of a very beautiful yellowish-white.

It

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or one fifth its weight of the zinc which rises from the calamine. The process consists in mixing three parts of calamine and two of copper with charcoal dust in a crucible, which is exposed to a red heat for some hours, and then brought to fusion. The vapours of the calamine penetrate the heated plates of copper, and add thereby to its fusibility. It is of great consequence, for the success of this process, to have the copper cut into small pieces, and intimately blended with the calamine.

2. In most foreign founderies the copper is broken small by mechanical means, with a great deal of labour; but at Bristol the workmen employ an easier method. A pit is dug in the ground of the manufacture, about 4 *feet* deep, the sides of which are lined with wood. The bottom is made of copper

It is remarkable that zinc, which is scarcely maleable, on being united with copper, produces malleable brass; whilst bell-metal is composed of malleable tin, and is so brittle, that it may be reduced to powder.

The specific gravity of bell-metal is likewise singular; for if the tin is about one-third of the mass, it is heavier than the brass itself; whilst, in other doses, it is only as heavy as the copper. Bell-metal is extremely hard and sonorous, and is less subject to alterations by exposure to the air, than any other cheap metal. On this account it is advantageously employed in the fabrication of various utensils and articles, as *canons*, *bells*, *statues*, &c. in the composition of which, however, other metals are mixed in various proportions, according to the fancy and experience of the artist.

White-

per or brass: and is moveable by means of a chain. The top is made also of brass with a space near the centre, perforated with small holes, which are luted with clay: through them the melted copper is poured, which runs in a number of streams into the water, and this is perpetually renewed by a fresh stream, that passes through the pit. As the copper falls down it forms itself into grains, which collect at the bottom. But great precaution is required to hinder the dangerous explosions, which melted copper produces, when thrown into cold water, which end is obtained by pouring small quantities of the metal at once. The granulated copper is compleatly mixed with the powdered calamine, and fused afterwards. The process lasts 8 or 10 hours, and even some days, according to the quality of the calamine.

3. It is a wonderful thing, says Cramer, that zinc itse being simply melted with copper, robs it of all its m

White-copper is prepared with arsenic. Neumann prescribes, to mix equal parts of arsenic and nitre, pulverized and mixed together, which being injected into a red-hot crucible, are to be kept in a moderate fire, till they subside and flow like fused wax. One part of this mixture is to be injected into four parts of melted copper; and the metal, as soon as it appears thoroughly united together, is to be immediately poured out. The copper is thus whitened; and if melted with a considerable part of silver, is so much improved, that vases, candlesticks, and various other pieces being made with it, hardly can be distinguished from true silver. The *white-copper* that is imported from China and Japan, seems to be nothing else than a mixture of *copper* and *arsenic*, since Geoffroy asserts that, by repeated fusions, arsenical fumes were exhaled from it; and at last the red copper was all that remained, having lost with its

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leability; but if it be applied in form of vapour from the calamine, the sublimates, or the flowers, it does not cause the metal to become brittle.

4. The method mentioned by Cramer to make brass from copper, by the volatile emanations of zinc, seems to be preferable to to any other process, as the metal is then preserved from the heterogenous parts contained in the zinc itself, or in its ore. It consists in mixing the calamine and charcoal with moistened clay, and raming the mixture to the bottom of the melting pot, on which the copper, mixed also with charcoal, is to be placed above the rammed matter. When the proper degree of heat is applied, the metallic vapour of the zinc, contained in the calamine, will transpire through the clay, and attach itself

its whitenefs one-feventh part of its former weight, as Lewis relates.

But the attention of the philofopher is more particularly directed to that kind of *white-copper* with which fpeculums of reflecting telefcopes are made [*h*]. *The Editor.*

SECT.

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felf to the copper, leaving the iron and the lead, which were in the calamine, retained in the clay, without mixing with the upper metal. Dr. Watfon fays, that a very good metallurgift, of Briftol, named John Champion, has lately obtained a patent for making brafs, by combining zinc in the vapourous form, with heated copper plates; and that the brafs from this manufacture is reported to be of the fineft kind; but he knows not whether the method there employed is the fame here mentioned from Cramer.

5. Brafs is fometimes made in another way, by mixing the two metals directly: but the heat requifite to melt the copper, makes the zinc burn and flame out, by which the copper is defrauded of the due proportion of zinc. If the copper be melted feparately, and the melted zinc poured into it, a confiderable and dangerous explofion enfues; but if the zinc is only heated and plunged into the copper, it is quickly imbibed, and retained. The union, however, of thefe two metals fucceeds better, if the flux, compofed of inflammable fubftances, be firft fufed in the crucible, and the copper and zinc be poured into it: as foon as they appear thoroughly melted, they are to be well ftirred, and expeditioufly poured out; or elfe the zinc will be inflamed, and leave the red copper behind.

6. Neumann fays, that 64 pounds of copper imbibe 26 pounds from the calamine, and yield 90 pounds of brafs. In general, all the yellow compounds are nothing elfe but the fame two fubftances in different dofes. When the zinc enters in a greater quantity into the brafs, the colour of the compounds becomes more and more pale. The quantity of zinc in good brafs may be about one third of the weight. *The Editor chiefly from* Cramer.

[*h*] 1. The beft proportions to make this kind of *white-copper*, are 32 *parts* of fine *red copper*, *one part* of brafs; *one*

part alſo of *ſilver*; 15 parts of *tin* (of the beſt ſort called *Grain-tin*); and about 3 *parts* of *white-arſenic*. The proceſs given by the late J. Edwards, who was rewarded by the *Board of Longitude*, for diſcloſing it to the public, was publiſhed in the Nautical Almanack for 1787; and is as follows: Melt the copper in a large crucible, employing ſome *black flux*, compoſed of 2 *parts* of *tartar*, and *one* of *nitre*; when melted, add to it the *braſs* and the *ſilver*. Let the *pure tin* be melted in another crucible, alſo with ſome *black flux*. Take them both from the fire, and pour the melted *tin* into the fuſed maſs in the large crucible. Stir the whole well with a dry ſpatula of *birch*, and pour off the fuſed metal immediately into a large quantity of cold water. The ſudden chill of the water will cauſe the fluid metal to divide into an infinite number of ſmall particles, which will cool inſtantly.

2. If the copper be compleately ſaturated, the fracture of one piece of this mixed metal will appear *bright*, and of a *glaſſy look*, reſembling the face of *pure quickſilver*. But if it is of a *brown-reddiſh colour*, it wants a little more *tin*. To aſcertain the required proportion, melt a ſmall quantity, known by weight, of the mixed metal, with a known very ſmall part of tin; and, if neceſſary, repeat the trial with different doſes, till the fracture of the new mixture looks as already deſcribed. Now having aſcertained the neceſſary addition of *tin* that is required, proceed to the laſt melting of the whole metal, together with the additional proportional doſe of tin; fuſe the whole, obſerving the ſame cautions as before; and you will find that the mixture will melt with a much leſs heat than that for the firſt fuſion. Have ready as many ounces of white arſenic in coarſe powder as there are pounds in the weight of the metal; wrap up the *arſenic* in a ſmall paper, and put it, with a pair of tongs, into the crucible; give it a good ſtir with the ſpatula, retaining the breath to avoid the arſenical fumes or vapours (which however are not found to be hurtful to the lungs) till they diſappear; take the crucible off the fire, clear away the droſs from the top of the metal, pour in about one ounce of powdered *roſin* with as much *nitre*, in order to give the metal a clean ſurface and pour out the metal into the moulded flaſks.

3. The *ſpeculum* ſhould be moulded with the concave ſurface downwards, and many ſmall holes ſhould be made through

SECT. 333. (201.)

Iron. *Ferrum*, *Mars*, Lat. *Jern*, Swed. *Eisen*, Germ. *Fer*. French.

General Properties of Iron. [*a*].

This metal is

a. Of a blackish blue shining colour,

It

through the sand upwards, to discharge the air. The moulding sand from *Highgate* near London, used by the founders, is as good as any, for casting these metallic mirrors.

N. B. The cast metal should be taken out from the sand of the flasks, whilst it is hot; or else it may happen to crack, if let to cool within. *The Editor.*

[*a*] 1. Iron is the most diffused and the more abundant of all metallic substances; since it is not only found either intermixed with, or united to, all the *fossil bodies* of the earth; but also, in combination with the productions of the two other kingdoms of nature, the *vegetable* and the *animal bodies*, whose juices and blood are coloured by it; and there is even a probability that these organic substances have the power of producing this metal by themselves; for it is known that it may be extracted even from the ashes of those plants that had been raised in pure water. Iron is contained in almost all the coloured stones, even in the hardest and most brilliant gems, in the bitumens, moulds, and waters, and in the greatest number of metallic ores.

2. This metal in its reguline state is of a more or less *dark-blue* colour in various specimens. It may receive such a polish as to appear *white*; and, after being hardened, it may be polished so highly as to shine with an amazing brilliancy. However, it soon tarnishes, if exposed to the action of the atmosphere, and to moist air in particular; taking a dusky

b, It becomes ductile by repeated heating between coals, and hammering.

c. It is attracted by the loadstone, which is an iron ore; and the metal itself may also be rendered magnetical,

d, Its specific gravity to water is as 7,645, or 8000 : 1000.

It

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dusky blackish hue, and contracting a yellowish and reddish rust on its surface. Nevertheless, it has been observed that hard iron, or steel, well polished, has sometimes escaped being attacked by rust, under running water.

3. Iron has a particular and very sensible smell, when strongly rubbed, or heated. It produces a styptic taste, which it communicates to the water in which it is extinguished after ignition.

4. Its tenacity, ductility, and malleability, are very great. It exceeds every other metal in elasticity and hardness, when properly tempered. An iron wire of *one-tenth* of an inch thick, is able to support 450 pounds weight, without breaking, as Wallerius asserts.

5. Iron extends difficultly under the hammer, but it may be extended to a great degree, and drawn into wire as slender as the finest hairs. It is more easily malleable when ignited than when cold; whereas other metals, though ductile when cold, become quite brittle by heat.

6. It grows red-hot sooner than other metals: nevertheless, it melts the more difficultly of all, platina and manganese excepted. Exposed to a white heat, less than sufficient for its fusion, it contracts a semivitreous coat, which bursts at times, and flies off in sparkles. It does not tinge the flame of burning matters into bluish or greenish colours, like other imperfect metals, but brightens and whitens it; hence the filings of iron are used in compositions of fire-works, to produce what is called *white-fire*.

7. When strongly heated, it appears covered on its surface, with a soft vitreous matter like varnish; in this state pieces of iron may be made to cohere to one another, by being hammered together; this is called the *welding* of iron; the joint unites so well as not to be discovered afterwards, if properly made.

e. It calcines easily to a black scaly calx, which, when pounded, is of a deep red colour.

f. When this calx is melted in great quantity with glass compositions, it gives a blackish brown colour to the glass; but in a small quantity a greenish colour, which at last vanishes,

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made. This property of *welding* is not found in the other metals.

8. *Iron*, or rather *steel*, expands the least of all hard metals by the action of heat; but *brass* expands the most; and on this account these two metals are employed in the construction of *compound pendulums* for the best sort of regulating clocks, for astronomical purposes. Each of these pendulums consist of 5 rods of steel, and 4 of brass; and, on account of their appearance, are called *grid-iron pendulums*. These 9 rods are placed in an alternate order, the middle rod being of steel, and suspending the lenticular ball. They are so connected with each other at their ends, that while the expansion of the steel rods has a tendency to depress the center of oscillation, the expansion of brass-rods acting upwards, tends to raise it; and, being duly proportioned, their expansions balance and correct each other, preserving the pendulum of the same length in any different temperature of the atmosphere.

The late ingenious John Harrison was the inventor of this useful contrivance about the year 1725 or 26; and it is rather singular, that the laborious Musschenbroek attributes this invention to G. Graham, in the article 674 of his *Introduction to Natural Philosophy*, only because the first pendulum he heard of this kind, had been made by this last excellent artist.—Mons. De la Lande, however, has done justice to the real inventor, in the article 2462 of his Astronomy, where he describes this construction; and its great advantages for the regularity of the going of astronomical regulators.

9. It appears, however, from the experiments of Mr. Smeaton in the *Philos. Transact.* for 1750, that zinc suffers still a greater expansion from the same quantity of heat, than

vanishes, if urged by a strong degree of heat.

g. It is dissolved by all salts, by water, and likewise by their vapours. The calx of iron is dissolved by the spirit of sea-salt, and by aqua regia,

The

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any other metal. Consequently fewer rods of steel and zinc may produce the same effect when properly combined. Only 3 rods of steel, and *two* of zinc, mixed with some *silver*, produce, in our best English regulators, the very same effect which formerly required almost double the number of these metallic rods. The following table of the expansions of different metals, observed by Mr. Smeaton, with his new Pyrometer, is extracted from the XLVIIIth vol. of the Phil. Transact. p. 612.

13. *Table shewing what is the expansion of a* foot of *the following* metallic substances, *by the* temperature of 180 *degr.* of Fahrenheit's thermometer, *viz. from the* freezing point *to that of* boiling water, *expressed* in 10,000 *parts of the English inch.*

White glass barometer tube	100	Spelter solder, viz. brass 2. zinc 1.	247
Martial Regulus of antimony	130	Fine pewter	274
Blistered steel	138	Grain tin	298
Hard steel	147	Soft solder, viz. lead 2. tin 1.	301
Iron	151	Zinc 8. tin 1. a little hammered.	323
Bismuth	167	Lead	344
Hammered copper	204	Zinc or spelter	353
3 parts of copper with 1 of tin	218	Zinc hammered an inch per foot.	373
Cast brass	225		
16 parts of brass with 1 of tin	229		
Brass-wire	232		
Speculum metal	232		

11. Iron, in the act of fusion, instead of continuing to expand, like the other metals, shrinks, as Dr. Lewis observes; and thus becomes so much more dense, as to throw up such part, as is unmelted, to the surface; whilst pieces of *gold*, *silver*, *copper*, *lead*, and *tin*, put in the respective metals in fusion, sink quickly to the bottom. But in its return

h. The calx of the dissolved metal proves yellow, or yellowish brown; and in a certain degree of heat, it turns red.

i. The same calx, when precipitated from acids, by means of the fixed alcali, is of a greenish colour; but it becomes blue, when precipitated

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turn to a consistent state, instead of shrinking, like the other metals, it expands; sensibly rising in the vessel, and assuming a convex surface, whilst the others subside, and appear concave. This property of iron was first taken notice of by Reaumur, and excellently fits it for receiving impressions from the moulds into which it is cast; being forced into their minutest cavities. Even when poured thick into the mould; it takes, nevertheless, a perfect impression; and it is observed, that cast iron is somewhat larger than the dimension of the mould; whilst cast figures of other metals are generally smaller.

12. The *vitriolic acid* dissolves iron readily, and forms the *green vitriol* of Sect. 207. This salt, in actual solution, is deprived of phlogiston by the contact of air, and the attraction between the acid and the metallic particles is diminished; a quantity of ochreous matter, or ferrugineous calx, therefore, falls to the bottom in this case, and the liquor, as well as the crystals, obtained by evaporation, are paler.

13. This acid, the vitriolic, requires to be diluted with 304 times its quantity of water, to enable it effectually to dissolve iron; and, during the dissolution, a strong aërial fluid arises, called *inflammable air*, which, on being mixed with atmospheric air, takes fire at the approach of the flame of a candle. A glass phial, of about two ounces measure, with one-third of *inflammable air*, and the rest of *common-air*, produces a very loud report, if opened in the same circumstance; and if it be filled with two-thirds of *inflammable air*, mixed with one of *dephlogisticated air*, the report will be as loud as the explosion of a pistol with gun powder. It is highly probable, and even demonstrated, that inflammable air is the true *phlogiston*, whose real existence some modern philosophers endeavour to overthrow. *See note* a *to page* 441: *and* Priestley's 2d vol. on *different kinds of air*, pag. 98 and 99.

Dilute

tated by means of an alcali united with phlogiston, in which last circumstance the phlogiston unites with the iron. These two precipitates lose their colour in the fire, and turn brown.

The

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15. Dilute *nitrous acid* dissolves iron, but this saline combination is incapable of crystallizing. Strong *nitrous acid* corrodes and dephlogisticates a considerable quantity of iron, which falls to the bottom.

Marine acid likewise dissolves iron, and this solution is also incrystallizable.

16. The *Prussian acid* precipitates iron from its solutions, in the form of *Prussian blue.*

N. B. An account of this acid will be given in the *Article of Assaying by the Humid way.*

17. This metal is likewise sensibly acted upon by alkaline and neutral liquors, and corroded even by those which have no perceptible saline impregnation; the oils themselves, with which iron utensils are usually rubbed to prevent their rusting, often promote this effect in some measure, unless the oils had been previously boiled with litharge, or calces of lead.

18. Galls, and other astringent vegetables, precipitate iron from its solutions, of a deep *blue* or *purple colour*, of so intense a shade as to appear *black.*

It is owing to this property of iron, that the common writing ink is made by the process described in the Note N° 9 to p. 405; although the doses and circumstances may be changed in different ways without affecting the success.

The infusion of galls, and also the Prussian alkali, are tests of the presence of iron, by the colours they produce on any fluid. Acids, however, dissolve the coloured precipitates by the former; and from hence arises that the marine acid is successfully applied to take off ink-spots, and iron stains from white linens. Alkalis, however, convert these iron-precipitates into a brown ochre.

20. Iron has a strong affinity with sulphur. If a bar of iron be strongly ignited, and a roll of brimstone be applied

to

k. The vitriol of iron is green.

l. It is the most common metal in nature, and at the same time the most useful in common life; notwithstanding which, its qualities are perhaps very little known.

SECT.

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to the heated end, it will combine with the iron, and form a fusible mass, which will drop down. A vessel of water ought to be placed beneath, for the purpose of receiving and extinguishing it, as the fumes would otherwise be very inconvenient to the operator.

21. A mixture of iron-filings and sulphur in powder, moistened with water, and pressed so as to form a paste, will in a few hours swell, become hot, fume, and even burst into a flame, if the quantity is large. The residuum furnishes martial vitriol. This process is similar to the decomposition of martial pyrites, from which some philosophers account for hot spring waters, and subterraneous fires. The mixture of water in this paste seems to be necessary to enable the vitriolic acid of the sulphur to act on the iron.

22. Iron is dissolved by all metals, made fluid by a sufficient heat, except *lead*, on which it floats distinct as oil upon water. Gold, of all metals, acts on it the most powerfully; though, as Cramer observes, if the iron contains any sulphur, it can scarcely be made to unite at all with gold.

24. It refuses likewise to unite to mercury; and no method has hitherto been discovered to amalgamate these two substances together, though in some circumstances a mutual cohesion has been observed to take place, as was noted at p. 580. Nº 3.

24. Among the semi-metals, *zinc* is the most difficultly combined with iron; not from a natural indisposition to unite, but from the zinc being difficultly able to sustain the due degree of heat. This mixture is hard, somewhat malleable, and of a white colour, approaching to that of silver.

25. *Regulus of Antimony*, as soon as it melts, begins to act on iron, and dissolves a great quantity of it. If this regulus, when fused, be stirred with an iron rod, the end of it will be

soon

two are from the *native iron*, found by Pallas on the Emir Mountains of Siberia [*b*].

SECT. 335. (202.)

Calciform Iron.

Iron is found in a calciform ftate [*a*].

In

[*b*] I was favoured with a fpecimen of this native iron from Siberia, by the generous friendfhip of Dr. Matthew Guthrie, refident at St. Peterfburg, who defcribed it to me by the following words, in his letter of the 9th of Sept. 1777. "N° 3d is a piece of the curious mafs of native iron, "difcovered by my friend Pallas, on a mountain in Siberia, "and is the firft inftance of this metal being found in this "very pure malleable ftate. The pores of it were filled "with a yellow vitreous matter, fo hard as to cut glafs, of "which I alfo fend a little in a paper apart, as it fell out "on cutting fpecimens from the large mafs. I am very "forry that the fpecimen of iron is fo fmall, but it is a "very good one, as it fhows not only the cellular texture of "the mafs, but the varnifh which Pallas fpeaks of, as lining "its hollows; and is exactly in fmall, what the mafs is in "large." On my receiving this curious and wonderful fpecimen, I found that every circumftance correfponded exactly to the defcription given by the Doctor. The little cells were like fpherical cavities; the varnifh ftill adhering to fome parts, appeared to be the contiguous cruft of the glaffy fubftance that was within; and the metallic mafs was perfectly malleable, and rather fofter than common iron. I made a prefent of this curious fample to my late worthy friend, the celebrated Dr. Fothergill, from whofe hands it probably has paffed to fome other cabinet; fince I was told, it was not found in his own, after his deceafe. *See Journal de Phyfique, fupplement, tom.* 13. *for* 1778, p. 128. The Editor.

[*a*] The bafis of the calciform iron-ores, is either the *black* or *blackifh brown* calx of iron, which is in fome meafure phlogifticated and magnetic; or the *red* calx of iron, which is

A. In form of calx, *Minera ferri calciformis pura.*

1. Pure.

a. Loose and friable, *Minera ferri calciformis pura friabilis.* Martial ochre, *Minera ochracea.*

1. Powdry, *Ochra ferri,* is commonly yellow or red: and is iron which has been dissolved by the vitriolic acid [*b*].
2. Concreted. Bog-ore.

a. In form of round porous balls.

b. More solid balls.

c. In small flat pieces, like cakes, or pieces of money.

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is more dephlogisticated, and not magnetic before torrefaction. *Kirwan.*

Among all iron ores, the most numerous are the calciform; and seem to be of a secondary formation, *viz.* they are formed by the deposition and precipitation from waters, as appears by their mixture with various heterogeneous substances, many of which have belonged to organised bodies: they may be, therefore, looked upon as resulting from the decomposition of other iron-ores, made by *water* and the *aerial acid*, with which the moisture that circulates through the earth is always impregnated. For this general acid attracts the phlogiston contained in the true metallic ores, and in the martial æthiops it meets with; and this by a gradual and constant action, which is so much the more efficacious, as its power never ceases its exertion during the existence of the metallic compound, until the whole is reduced into a calciform state, or a martial *crocus.* According to Mongez, these calciform iron-ores may be properly divided into 1. the *ochreous* contained in this section: 2. the *crystallized*: 3. the *hæmatites*; and 4. the swampy, which will be treated of in the following notes. *The Editor, from* Mongez.

[*b*] See Note *c* to Section 340, where the *argillaceous* and the *bog*, or *swampy* iron-ores, are described. *The Editor.*

d. In ſmall grains.

e. In lumps of an indeterminate figure.

All theſe are of a blackiſh brown, or a light brown colour. They are found in lakes in the province of Smoland; and in marſhes, at Fiellryggen, between the chain of rocks which ſeparates Sweden from Norway.

SECT. 336. (203.)

Indurated, pure, Calciform Iron-ores.

b. Indurated, *Minera ferri calciformis pura indurata.* The blood-ſtone, *Hæmatites* [a]. Of

[a] The name of *hæmatites*, or *blood-ſtones*, is not given to theſe ores on account of their external colour, for they are alſo *blue*, *yellow*, *brown*, and *micaceous*; but becauſe on being reduced to powder, or rubbed hardly, they produce a *red*, or *blood* colour. The yellow hæmatites, however, of Sect. 339, only give the *yellow* colour, when powdered.

They ſeem to be the reſult of the primitive iron-ores; and to have been formed like the ſtony concretions, and the earthy ſtalactites. They are fibrous, and ſtriated, like wood: ſome are formed in concentric layers, in oblong ſticks, or ſmall rods, in diverging radiations, and forming incruſtations to other extraneous bodies; generally they are of a hard conſiſtence; and ſome ſo much as to ſtrike fire on being ſtruck with hard-ſteel. The blackiſh hæmatites of Sect. 337. have a glaſſy ſhining fracture. The red ones of Sect. 338. to which the name of hæmatites more properly belongs, have ſometimes a colour approaching to the *purple*: when they have ſome calcareous mixture in their ſubſtance, as often happens, they make effervescence with acids. But in general they contain ſome little *argill*, and *mangneſe*. The hæmatical

1. Of an iron colour, *Hæmatites cærulescens.*

This is of a blueish-grey colour; it is not attracted by the load-stone, yields a red powder when rubbed, and is hard.

a. Solid, and of a dim appearance when broken.

b. Cubical, and of a shining appearance when broken.

c. Fibrous *(Sädig.)*, is the most common *Torrsten* of Sweden.

d. Scaly (iron glimmer), the *Eisenram* of the Germans.

This is for the most part as if it were testaceous, though the scales go across the strata of the stone. It is found at Jobsbo, at Norrberne in Dalarne, and Reka Klitt, in the province of Helsingland.

1. Black, from Gellebeck, in Norway.

2. Blueish-grey, from Reka Klitt.

When this is found together with marcasite, as at Sandswar in Norway, it is not

tical ores are not magnetic before torrefaction; but they become black, and magnetic, by fire.

These ores are productive of very good iron; and are found in great abundance in the province of Galiza, in the kingdom of Spain. The inhabitants of Compostelle, which is the capital town, make a good commerce of those hæmatites of the hardest kind, for the burnishing gold leaves, and various metals, therewith. Those I have seen employed to these uses were of the dark-blue kind, somewhat similar to black-lead. But there are many other parts in Europe, where these ores are plentifully found; and in some places they form whole mountains: they afford from 40 to 80 *per cent.* of metal. *The Editor, chiefly from* Kirwan, Mongez, *and* Bomare.

only attracted by the loadstone; but is of itself really a loadstone. Sect. 343.

e. Crystallised [*b*].

1. In octoédrical crystals.

2. In polyédrical crystals.

3. In a cellular form, from Mossgrufvan, at Norberg in Westmanland.

These varieties are the most common in Sweden, and are very seldom blended with marcasite, or any other heterogeneous substance, except their different beds.

[*b*] The most extraordinary iron ores of this kind, both on account of their forms, and of their various and brilliant colours, are found in the island of Elba, near the coast of Tuscany. The crystallized ores are the most common, the purest, and the most beautiful; and no where else similar specimens have been found. They exhibit various gradations of the finest colours, as *red*, *violet*, *blue*, *green*, *yellow*, *brown*, *black*; and look, according to Coudrai's expression, like so many clusters of precious *emeralds*, *sapphires*, *diamonds*, *rubies*, and *topazes*. I beheld, indeed, with astonishment, some of these specimens, for the first time, on a mantle shelf of a private house at *Porto Longone*, where I touched on my sailing to Italy, at the end of 1755, soon after the earthquake of Lisbon; and have seen ever since many specimens of the kind in various collections; but they lose great part of their brilliancy on being exposed to the moisture of the atmosphere. These ores have no other mineralizer, but the *aerial acid*, as E. Pini and Mongez assert, against the opinion of Coudrai, who pretends that they contain Sulphur. Besides these crystallized ores, there are in the mines of Elba, various other iron-ores, such as of the *hæmatite kind*, the *ochreous*, the *magnetical*, the *swampy*, and the *sandy ones*. The whole island seems in fact to be a group of iron-mountains: its ores in general produce the best kind of malleable iron: and very great advantages would arise from these mines, if more skilful managers were employed in conducting their works. *The Editor, from* E. Pini, Coudrai, Mongez, *and* Ferber's *observations*.

It

It is remarkable, that, when these ores are found together with marcasite, those particles, which have laid nearest to the marcasite, are attracted by the loadstone, although they yield a red or reddish-brown powder, like those which are not attracted by the loadstone.

It is likewise worth observation, that they generally contain a little sulphur, if they are inbedded in a lime-stone rock, which, however, very seldom happens in Sweden; but I know only one such instance, *viz.* at Billsio, in Soderberke, in the province of Dalarne. Sect. 345.

SECT. 337. (204.)

Black Hæmatites.

2. Blackish-brown bloodstone, *Hæmatites nigrescens*. Kidney ore.

This yields a red-brown powder when it is rubbed; it is very hard, and is not attracted by the loadstone.

a. Solid, with a glassy texture, from Westersilfverberget, in the province of Westmanland.

b. Radiated.

c. Crystallised.

1. In form of cones, from Siberia.
2. In form of concentrick balls, with facets.

These are very common in Germany, but very scarce in Sweden.

SECT. 338. (205.)

Red Hæmatites.

3. Blood-red, *Hæmatites ruber.* Red kidney ore.

a. Solid, and dim in its texture, from Wester-silfverberget, in Westmandland.

b. Scaly. The *Eisenram* of the Germans. This is commonly found with the iron-coloured iron-glimmer (Sect. 336. *d.* 1.), and smears the hands.

c. Crystallized.

1. In concentrick balls, with a flat or facetted surface.

SECT. 339. (206.)

Yellow Hæmatites.

4. Yellow bloodstone, *Hæmatites flavus.*

a. Solid.

b. Fibrous, from Lammerhof, in Bohemia [*a*].

SECT.

[*a*] This yellow blood stone, when reduced into powder, retains the same colour it had before: as has been already remarked in the note [*a*], to Sect. 336, p. 724. *The Editor.*

The varieties of the colours in the blood stones are the same as those produced in the calces of iron, made by *dry* or *liquid* menstrua, and exposed to different degrees of heat. *The Author.*

See

SECT. 340. (207.)

Heterogeneous iron-ores.

2. Iron in form of calx, mixed with heterogeneous substances. *Minera ferri calciformis heterogeneis mixta.*

a. With a calcareous earth. White spathose iron ore. The *Stahlstein* of the Germans. See Sect. 36 [*a*].

With

See the note to Section 248. upon the succession of colours exhibited by iron, when it is growing hot. *The Editor.*

Yellow ochres are distinguished from clays, by containing a larger portion of martial particles; those that become brown and magnetic by calcination, belong to this species. Sometimes the ferrugineous particles are mixed with argill, and calcareous, or muriatic earths; and then these ochres effervesce with acids. Kirwan, Sp. 8.

[*a*] The *sthalstein*, or *Weiss Eisen Spath* of the Germans, is whitish, when fresh dug; but it becomes *grey* afterwards, then *brown*, at last *reddish*, *yellowish*, and *black*. It is either amorphous, or rhomboidal; is frequently transparent, and of a *lamellar* texture, or *scaly*, *granular*, or *cellular*. Sometimes it assumes a *stalactitical* form, and sometimes is found in a *powdery* state; in this last case it is of a brown-blackish colour; is frequently interspersed with *quartz*, *pyrites*, *shoerl*, *zeolyte*, *mica*, and *asbestos*. It will not give fire with steel, unless these foreign substances be struck.

Its specific gravity is from 3,600 to 3,895, or 4,000. It effervesces feebly with acids, particularly when pounded and heated. It is scarcely ever magnetical before calcination; but, if heated, it decrepitates, grows black, becomes magnetic, and loses from 15 to 40 *per cent.* of its weight. 100 parts of this ore from *Eisenärtz* in *Stiria* afford, according

to

b. With a filiceous earth. The martial jafper, or finople. Sect. 108. [*b*].

With

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to Bergman, 38 of brown calx of iron, 24 of white calx of manganefe, and 38 of mild calcareous earth. That of *West Silvretberg* contains 22 of the faid calx of iron, 28 of manganefe, and 50 of mild calcareous earth.

N. B. The aerial acid is not only united to this laft earth, but alfo to the metallic calces.

When this ore bears a ftalactitical appearance, and is very white, it is called *Flos Ferri*, and *Eifen Bluth*. This affords 27 *per cent.* of reguline iron, according to Rinman; and confequently 35 of the brown calx. *Editor, from* Kirwan, Sp. 5.

Befides the *ftahlftein*, mentioned by the author, there is a red calcareous iron ore found in many parts of England, in a loofe form. It effervefces ftrongly with acids, and is ufed as a pigment. *Kirwan*, Sp. 14.

[*b*] Befides the two filiceous combinations, mentioned by the author in thefe two laft articles, the *jafper*, *garnet*, and *trapp*, (which laft will be mentioned in the Appendix among the *volcanic productions*), and various other compound fubftances, contain iron. There is found, principally in France, a *black*, *heavy*, *unmagnetic* fand, of the filiceous kind, which is faid to contain *iron* and *zinc* in great quantity.

The *black fand* from Virginia contains about half its weight of iron, and is magnetic. Its fpecific gravity is=4,600, but its compofition has not yet been difcovered. *Kirwan*, Sp. 6.

It appears, by the account inferted in the Philof. Tranfactions for 1763, p. 56, that there are very large quantities of this *fand-iron-ore* in Virginia, perhaps as large as of any other kinds of iron-ore. It is fo pure, that it required a mixture of *bog-ore*, or of *flags* from other fmeltings, to reduce it to a metallic form. The iron and fteel produced from it, was above 60 *per cent.* (or 50 from 85): the quality both of the *iron* and of the *fteel*, made out of this ore, was extremely good, and two fmall bars of the fame were fent, as a fample, to the Mufeum of the Royal Society of London.

Large

c. With a garnet earth. Garnet and cockle, or ſhirl. Sect. 115 to 123.

d. With an argillaceous earth. The bole, Sect. 134 to 136. [*c*].

With

Large ſtrata of black-ſand iron-ore are found in various places of Portugal, even at a conſiderable diſtance from the ſea-ſhore, and from any running waters; a very great part of this black-ſand is attracted by the magnet; but I do not know, whether its component parts have ever been properly examined. *The Editor.*

Baron Born, in his letters from Hungary, quoted by Mr. Kirwan, mentions a blue cryſtallized iron-ore, which he ſays is a *ſhoerle* over-loaded with iron. *See also the note to p. 212.*

The ſame Mr. Kirwan, at p. 143 of his *Elements of Mineralogy*, ſpeaks of a ſiliceous ſand, conſolidated by ſemi-phlogiſticated calx of iron, which does not crumble into ſand when powdered. It is generally of a *brown* or *black* colour; but grows *reddiſh* or *yellowiſh*, and moulders by expoſure to the air. Its ſpecific gravity is from 2,800 to 3,600: it gives fire with ſteel, and does not effervesce with acids, unleſs it contains teſtaceous particles, as it frequently does, and is even often covered with ſhells.

He adds, that the agglutinating power of ſolutions of iron has been ſhewn by a ſtony concretion of this ſort, that had been long buried in the ſea, and is mentioned in a paper of Mr. Edward King, inſerted in the *Philoſ. Tranſactions* for 1779, p. 35. Mr. Rinman has found, by experiment, that dephlogiſticated calces of iron, and particularly its ſolutions made by mineral acids, have no binding power; on the contrary, they only make looſe concretions. *Kirwan.*

[*c*] The argillaceous iron-ores may be diſtinguiſhed into two varieties, namely, thoſe found in mountains and high lands, and thoſe found in ſwampy grounds, and low lands overflown with water; both are deſtitute of metallic luſtre, but very weighty, and ſome of them, when dry, abſorb water like clay.

The Highland ochraceous-ores of the argillaceous kind are either of a *yellow*, *red*, *brown*, or *greyiſh* colour; are

friable,

e. With a micaceous earth. Mica. Sect. 65. [*d*].
f. With manganese. [*e*].

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friable, loose, and powdery, or in *grains*. They consist chiefly of the calx of iron, in a loose form, mixed with argill or clay, and frequently contain manganese: some in *France*, and in the neighbourhood of *Liege*, contain also the calx of *zinc*. They do not effervesce with acids, unless calcareous or muriatic earths be mixed with them; and never obey the magnet before calcination, and rarely after it.

Horn stone, overloaded with iron, belongs to this species.

Rinman mentions a *white* iron-ore, found in Kent, mixed with clay, or marl, which affords 47 *per. cent.* of brittle iron; and is scarcely soluble in acids.

The *swampy* or *lacustris* iron-ore is friable, brown, brownish, or black. It is found either in lumps, of an irregular shape, or in balls or in grains; and also in slender triangular prisms parallel to each other. It is mixed with argill, and extractive matter: becomes magnetic after calcination, by which it loses about $\frac{1}{4}$ of its weight, whose greater part is water, and the remainder is aërial acid and volatile alkali. The crude ore affords about 30 *per cent.* of regulus; and, after calcination, about 50 *per cent.* The iron produced from this ore, chiefly that in Sweden, is of the *cold-short* kind. Mr. Hielm found some sorts of this ore, which contain 28 *per cent.* of manganese. *The Editor, from* Kirwan.

[*d*] When the *micaceous iron-ores* produce a red colour on being rubbed between the fingers, they belong to the *hæmatite kind*; and have been mentioned in note [*a*] to Sect. 336. But there are others that properly belong to this section; such is, for instance, that kind of serpentine overloaded with iron, which may be called *muriatic iron-ore*; but it is seldom worked, if ever, to extract the metal. *The Editor, from* Kirwan.

[*e*] The iron ores, mixed with manganese, have been already mentioned in the two preceding notes [*a*] and [*c*]. *The Editor.*

SECT.

SECT. 341. (208.)

Native Pruſſian blue, or *Alkaline Iron-ore.*

g. With an alcali and phlogiſton. *Calx martialis phlogiſto juncta, et alcali precipitata.* Blue martial earth. Native Pruſſian-like blue.

1. Looſe or powdery, found among the turf in the levels of the province of Skone: alſo in Sax Weiſſenfels, and at Norvlanden in Norway, &c. [a].

SECT.

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[a] This ore conſiſts of clay mixed with iron, and ſome unknown tinging ſubſtance. It is generally found in ſwampy grounds or bogs. At firſt its colour is white; but when expoſed to the air, it becomes either of a *white*, or of a deep *blue*.

When heated, it turns greeniſh, and emits a ſlight flame; afterwards turns red, and magnetic.

Is ſoluble in acids and alkalis, but the latter precipitate it from the former, and the former from the latter. The precipitate is at firſt greeniſh; but gradually aſſumes a white hue; and recovers the blue tinge, if it be ſteeped in vegetable aſtringents. The earth of *Benthnitz*, in *Silefia*, ſeems to belong to this kind. It produces $\frac{1}{4}$ of its weight of iron.

Mr. Woulf found alſo this kind of ore in Scotland, on the ſurface of the earth, in the form of a fine white powder. The greateſt part of marſhy grounds, where the turf is found, generally contains ſome of this kind of iron ore. *The Editor, from* Kirwan *and* Mongez.

The *Terre verte*, called *Earth of Verona* and *Normandy*, is uſed as a pigment, and contains iron in ſome unknown ſtate, mixed with *clay*; and ſometimes with *chalk* and *pyrites*. *Alum* and

SECT. 342. (209.)

Cementing iron-ore. *Terras, cementum.*

b. Iron-ore with an unknown earth, which hardens in water.

Calx martis terrâ incognitâ indurescente mixta. Terras. *cementum* [a].

1. Loose or granulated, *Terra Pozzolana*, from Naples and Civita Vecchia in Italy. This is

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and *selenite* are also accidentally found with it. It is difficultly soluble in acids: is not magnetic before calcination, and becomes of a coffee-colour when heated. It is said to afford about 40 *per cent.* of iron.

N. B. If iron be precipitated from vinegar by the arsenical acid, the precipitate will be green, and will preserve its colour, though exposed to the air. Iron precipitated from the marine acid by lime-water is frequently green; and green fluors are known to derive their colour from iron. The molybdenous acid (Sect. 162.) gives also a green colour to iron; but this fades. *The Edit. from* Kirwan, Sp. 26.

[a] The *Traass*, or *Terras*, differs but little in its principles from *pozzolana*, which will be spoken of in the following note: but it is much more compact and hard, porous and spungy. It is generally of a *whitish yellow* colour, and contains more heterogeneous particles, as *spar*, *quartz*, *shoerl*, &c. and sometimes more of calcareous earth. It effervesces with acids, is magnetic, and fusible *per se*. When pulverized, it serves as a cement, like pozzolana. It is found in Germany and Sweden. Kirwan, pag. 81.

The

is of a reddish brown colour, is rich in iron, and is pretty fusible [b].

Indurated,

[b] The *Terra pozzolana* is a volcanic product, composed of heterogeneous substances, thrown out from the burning mouths of volcanos, in the form of ashes; sometimes in such large quantities, and with so great violence, that whole provinces have been covered with it at a considerable distance. In the year 79 of the common era, the cities of Herculaneum, Pompeia, and Stabia, although at the distance of many miles from Vesuvius, were, nevertheless, buried under the matters of these dreadful eruptions; as Bergman relates in his *Treatise of the Volcanic Products*.

This volcanic earth is of a grey, brown, or blackish colour; of a loose, granular, or dusty and rough, porous or spungy texture, resembling a clay hardened by fire, and then reduced to a gross powder. It contains various heterogeneous substances mixed with it.

Its specific gravity is from 2,500 to 2,800; and it is, in some degree, magnetic: it scarcely effervesces with acids, though partially soluble in them.

It easily melts *per se*; but its most distinguishing property is, that it hardens very suddenly when mixed with $\frac{1}{3}$ of its weight of lime and water; and forms a cement, which is more durable in water than any other.

According to Bergman's Analysis, 100 parts of it contain from 55 to 60 of *siliceous* earth, 20 of *argillaceous*, 5 or 6 of *calcareous*, and from 15 to 20 of iron.

It is evidently a *martial-argillaceous* marl, that has suffered a moderate heat. Its hardning power arises from the dry state of the half-baked argillaceous particles, which make them imbibe water very rapidly, and thus accelerates the dissication of the calcareous part; and also from the quantity and semiphlogisticated state of the iron contained in it.

It is found not only in Italy, but in France, in the Provinces of *Auvergne* and *Limoges*; and also in England, and elsewhere; *The Editor, from* Kirwan, pag. 80 *See what has been said already by the* Author on this subject, *at the end of Sect.* 45, *pag.* 72.

Mention

2. Indurated, *Cementum induratum*, from Cologne [c].

This is of a whitish-yellow colour, contains likewise a great deal of iron, and has the same quality with the former, to harden soon in water, when mixed with mortar. This quality cannot be owing to the iron alone, but rather to some particular modification of it, occasioned by some accidental causes; because these varieties rarely happen at any other places, except where volcanos have been, or still exist, in the neighbourhood.

SECT. 343. (211.)

B. Dissolved, or mineralised Iron. *Ferrum mineralisatum.*

1. With sulphur alone.

a. Perfectly saturated with sulphur, *Ferrum sulphure saturatum.* Marcasite. See Sulphur, Sect. 254.

b. With very little sulphur. Black iron ore. Iron stone. *Minera ferri atra* [a].

This

[c] Mention has been made already in Sect. 132. p. 234, of a *colnish pipe clay*, which, when indurated, may answer to this *cementum induratum*, spoken of in the present Section. But this I must leave to the judgement of the reader, as I have no other clear idea of this substance. *The Editor.*

[a] This is the *Stahlertz*, or *ferrum chalybeatum*, of Linnæus; *viz.* a brown calx of iron, mixed with iron in

This is either attracted by the loadstone, or is a loadstone itself, attracting iron; it resembles iron, and yields a black powder when rubbed.

1. Magnetic iron-ore, *Minera ferri attractoria.* The Loadstone, *Magnes* [b].

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in its metallic state. Is of a dark steel colour, solid, compact, and shining in its fracture; scarcely gives fire with steel, produces a black powder; is magnetic, and, in some degree, malleable when red-hot. It affords from 60 to 80 *per cent.* of good iron. It is found at *Adelfors*, and *Dannemora* in *Sweden*: also in the *Isle of Elbe*, and *North America*. Kirwan.

The *crystallized iron ore* belongs to this kind. It is in an octahedral, or cubic form: is the *ferrum tessulare* of Linnæus, and the *minera ferri crystallisata* of Wallerius; it is somewhat less magnetic than the preceding ore; probably because it contains less of the metallized iron. *Kirwan*, pag. 271.

[b] This differs but little in its appearance from the preceeding ore, but has less lustre. It is either coarse or fine grained. The coarse grained loses its power soonest. It seems to contain a small quantity of sulphur, as it smells of it when red-hot. It is probable that it contains more particles of iron in its metallic state than the preceding ore; but it is often contaminated with a mixture of *quartz* and *argill.* It is possible it may contain *nickel*; for this, when purified to a certain degree, acquires the properties of a magnet. Its constitution has not yet been properly examined. *Kirwan*, Spec. 3.

The magnetical attraction seems to stand alone among natural phenomena. Philosophers observe its effect with surprize and admiration, whilst the most cautious and rational are obliged to confess that the cause is intirely unknown, as *Nicholson* observes (Book 3. Sect. 2); but, although this cause be not felt nor perceived by any of our senses, we are absolutely compelled to allow the existence of an extremely subtle matter, which is capable of producing this effect. Perhaps! time will discover, whether it be coercible by any other substance; or what is necessary to be done before it can be exhibited alone, or in a separate state. *The Editor.*

a. Steel-grained, of a dim texture, from Hogberget, in the pariſh of Gagnœf in Dalarne: It is found at that place almoſt to the day, and is of as great ſtrength, as any natural loadſtones are ever commonly found.
b. Fine-grained, from Saxony.
c. Coarſe-grained, from Spetalsgrufvan, at Norberg, and Kierrgrufvan, both in the province of Weſtmanland. This very ſoon loſes its magnetical virtue.
d. With coarſe ſcales, found at Sandſwœr in Norway. This is a pyritical *Eiſenman*, and yields a red powder when rubbed. Sect. 336.

S E C T. 344. (212.)

2. Refractory iron-ore. *Minera ferri refractoria.*

This ore, in its crude ſtate, is attracted by the loadſtone.

a. Giving a black powder when rubbed, *Tritura atra.* Of this kind are [a],
1. Steel-grained, from Adelfors, in the province of Smoland.
2. Fine-grained, from Dannemora, in the province of Upland.

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[a] Probably the *iron-blende*, deſcribed by Mr. Monnet, and mentioned by Mr. Kirwan in his Sp. 23, belongs to this kind of ore. This iron-blende is a ſtone of a grey iron colour, formed of diverging laminæ, of great hardneſs, and a metallic appearance; but is inſoluble in acids, and infuſible in the ſtrongeſt fire. Sometimes this ſtone contains arſenic; and in this caſe it blackens by expoſure to the air. *The Editor.*

Coarſe-

3. Coarse-grained, from Kierrgrufvan, in the province of Westmanland.

This kind is found in great quantities in all the Swedish iron mines; and of this most part of the fusible ores consist, because it is commonly found in such kinds of rocks as are fusible: and it is as seldom met with in quartz, as the hæmatites is met with in limestone.

SECT. 345. (213.)

b. Red-grained Iron ore, Tritura rubra,

This iron-ore differs from the preceding, on account of its rubbing into a red powder, *tritura rubra.*

These are real hæmatites, that are so far modified by sulphur or lime, as to be attracted by the loadstone [*a*].

1. Steel-grained, found in a deserted mine at Billsio, in the parish of Soderberke in Dalarne.

[*a*] These ores are very scarce in Sweden, for the most part of the Swedish blood-stones are pure, as has already been said, in the Sect. 336. They form that very profitable ore called in Swedish *Torrsten*. The Author.

The *Torrsten* consists of a red calx of iron, mixed with a small proportion of the brown ore; and is indurated. It is of a bright bluish-black, or yellowish-grey colour, and of a fibrous texture, shows a red trace when scratched, and is weakly magnetic before calcination. According to Rinman, it is less dephlogisticated than hæmatites. *The Editor from* Kirwan, Sp. 10.

2. Fine-grained. Emery. This is imported from the Levant. It is mixed with mica, is strongly attracted by the loadstone, and smells of sulphur when put to the fire [b].
3. Of large shining cubes, from Thomsensgrube at Arendal in Norway.
4. Coarse, scaly. The *Eisenglimmer* or *Eisenman* from Gellebeck in Norway [b].

SECT. 346. (214.)

Iron mineralised, or mixed.

Iron is found mineralised and mixed with various fossil substances.

Iron mineralised by sulphur. *Martial Pyrites* [c].

With

[b] Emery, according to *Kirwan*, *Sp.* 11, seems to be a mixture of the red and white calces of iron, with some unknown stony substance, perhaps *tripoli* (Sect. 143); it scarcely yields in hardness to any substance, except diamond.

The best sort is of a dark grey colour, but becomes brown; and in great measure magnetic by calcination.

Other sorts are of a reddish rusty white, or yellowish colour.

Its specific gravity is from 3,000 to 4,000.

It is never used as iron ore, nor is its proportion of iron well known. *The Editor.*

[c] The *martial Pyrites* are stony concretions of *sulphur*, *clay*, and *calx* of iron; so hard as to give fire with steel, from whence their name is derived. There are two principal varieties of them; the first is,

The

With arsenic, *Ferrum arsenico mineralisatum*; Called Mispickel by the Germans, and Plate Mundic in Cornwall [d].

With

The pale yellow pyrites, which are real iron ores, containing from $\frac{1}{6}$ to $\frac{1}{3}$ of sulphur, and from $\frac{1}{8}$ to $\frac{5}{8}$ of iron; the remainder is *argill* and *siliceons* earth, combined with each other, and the iron is in a semi-phlogisticated state.

They are of a yellow or grey colour, and of a globular, or cubic shape, internally radiated, and sometimes lamellar; commonly are partly soluble in *n·t· ous acid* with effervescence; and slowly in the *vitriolic*; with which they form alum. *See Sect.* 200.

They detonate slightly with nitre, and are very infusible. Their specific gravity is from 7,3000 to 4,912. See Sect. 254, and the following.

Some *pyrites*, instead of *argillaceous*, contain *calcareous* earth; these are common in *France*, and in them the iron is, according to *Monnet*, in a dephlogisticated state; *Pyrites* are frequently found in a stalactitical shape, and often form the matter of petrifications. They are also found mixed and interspersed through almost every other species of stone, except *granite*. According to the same *Monnet*, those pyrites which are of a *filamentous*, or *striated* texture, contain the least sulphur; and those of a *lamellar*, most: the last effloresce difficultly, if at all; and are said to contain from 25 to 35 *per cent.* of sulphur. *Kirwan*, pag. 190.

[*d*] The *Mispickel*, called *Speiss* by the Bohemians, is in general of a bright white, resembling a mixture of *silver* and *tin*; sometimes, though rarely, variegated, like a pigeon's neck, and not easily altered by exposure to the air. Its form is either granular, cuspidated, cuneiform, prismatic, or rhomboidal.

Is not magnetical before, nor after calcination; but when iron contains less than $\frac{1}{16}$ of arsenic, it is then magnetic; therefore, if the calcination of mispickel be pushed so far, the iron will remain magnetic.

Is soluble in acids, and affords arsenic by distillation, in the proportion of 30 or 40 *per cent.* and it sometimes contains a small proportion of *copper* and *silver*.

It

With sulphurated arsenic.
Arsenical Pyrites [c].
With vitriolic acid. Martial vitriol, Sect. 207 [d].

It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, shoerls, &c. *The Editor from* Kirwan, *Spec.* 20.

[c] This iron-ore is in the form of white grey pyrites, or marcasite; and is called by the Germans *Raush gelb kiess, Gift kiess,* or *Arsenic stein.*

It is found either in solid compact masses of a moderate size, or in grains.

It gives fire with steel.

When burnt, it affords a blue flame, and an arsenical smell, like garlick.

By distillation it affords *orpiment,* or *realgar.*

It is not magnetic, either before or after calcination; and contains much more arsenic than sulphur.

It is analysed by digestion in *marine* acid, to which the *nitrous* must be gradually added; otherwise the sulphur would be destroyed.

The *marine* acid will take up the *iron* and leave the arsenic; otherwise, if it be analysed by solution in *aqua regia,* both the *sulphur* and the *arsenic* will be dissolved; but, on adding water, the *arsenic* will be precipitated, and the iron will remain in the solution. The *silver* if any will remain in the form of horn-silver. *The Editor from* Kirwan's *Sp.* 19 and 20.

[d] This is a *brown,* or *reddish-brown* pyrites, called *Minera ferri hepatica* in Latin, and *Wasser Kiess* in German. It is generally of a spherical shape, crystallized in cubic, rhomboidal, or other polyhedral forms, and has no metallic lustre.

It difficultly gives fire with steel, and contains very little sulphur, but much more iron than the yellow pyrites; and not unfrequently a mixture of *calcareous earth.* It is sometimes magnetic before, and always after, calcination. It is incapable of vitriolization. The iron it affords is brittle. *Kirwan,* Sp. 18. Var. 2.

With

With phlogiston. Martial coal-ore. Sect. 258. B. 1. 2. [e].

With other sulphurated and arsenicated metals. See these in their respective arrangements [f].

SECT. 347. (215.)

Observations on Iron [a].

This metal enters into so many compositions, that they cannot all be possibly enumerated

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[e] This combustible iron-ore, already described in Sect. 258, is a kind of coal, of which there are the two varieties there mentioned. The *volatil* seems to contain *iron*, *plumbago*, and *coal*, intimately mixed; and the other burns with a languid flame, looses about $\frac{1}{5}$ of its weight, and yields about 30 *per cent.* of iron. *Kirwan*, pag. 283.

[f] The combination of *sulphurated* iron with *zinc*, generally called *Calamine*, will be treated hereafter among the ores of that semi-metal.

That with the *Tungsten* mentioned by the Author in his Sect. 210, will be treated on the article of Wolfram among the semi-metals.

And that with *Manganese*, will be also treated on the Sections upon this semimetal. *The Editor.*

[a] 1. Iron is employed in three different states, each having its peculiar properties, by which they are each more particularly applicable to various purposes. The first is *cast-iron*, the second is *wrought* or *malleable iron*, and the third is called *Steel.*

According to Bergman, *cast iron*, which may be called *unripe* or *raw-iron*, contains the smallest share of phlogiston. The malleable iron contains the greatest quantity, and the *steel* a middling share between both, neither so much as the rated; it must therefore suffice to mention only those, in which it makes the predominant part. This metal is found in animals and vegetables; and certain iron-ores seem to be of service to the

malleable, nor so little as the *cast-iron*. This last is called also *Pig-iron*, and *Yetlin* in England.

2. The richest ores of iron are the compact and ponderous, of a brownish, reddish-brown, or red colour. Some of these ores, in colour and appearance, do not ill resemble iron itself; as the grey ores of Derbyshire, and the bluish of the Forest of Dean in Gloucestershire. Most of the Swedish ores are likewise of this kind. Others are blackish, brown, red, yellowish, or rusty coloured, as have been described in the preceding Sections: these are the most common in England and Germany. There is one very singular species of a striated texture, and of a pale yellowish or greyish colour, oftentimes white, and in some degree pellucid; which, although in its crude state, promises nothing metallic; nevertheless, on being moderately calcined, discovers, by the deep colour it assumes, that it abounds in iron. Cramer informs us, that it gives out by fusion, from 30 to 60 *per cent*. But some richer ores yield no less than 70 and 80 on the hundred.

3. Different kinds of iron ore are found adhering, in some mines, to the tops of caverns, in form of icicles or striæ, sometimes irregularly clustered together, sometimes hanging down like the bristles of a brush; from whence the name of *Brush-iron-ore*. Other particular forms of the iron stone have occasioned a variety of fanciful names, that are met with in some of the metallurgic writers.

4. The iron of Great Britain is made from three different kinds of ores: 1. From the iron-ore, called the *Lancashire ore*, from the county where it is found in greatest abundance. This ore is very heavy, of a fibrous or lamellated texture; it is of a dark purple, approaching to a shining black; and, when reduced to powder, it becomes of a *deep red*: it lies in veins like the ores of other metals: 2. The bog-ore, which resembles a *deep yellow* ochry clay, and seems to be the deposition of some ferruginaceous rivulets, whose currents had formerly

the vegetable kingdom, as it is manifestly seen on the ground, around and under the heaps of loose stones laid up on separating the ore from the rock, at those iron mines, where the ores are mixed with limestone.

With

---

merly been over the surface of those flat marshy plains. It lies in beds of irregular thickness, commonly from 12 to 20 *inches*, and very various in their breadths from side to side, never being of great dimensions. 3. The iron-stones, however, have no regular appearance, and do not in the least resemble a metal in their external surface. They lie often in beds of great extent, like other stony matters, and are sometimes stratified with seams of pit-coal, forming alternate layers.

5. The ores of iron are commonly calcined, previous to the fusion, even the harder ones, though they should contain nothing *sulphureous* or *arsenical*, in order to calcine the hard adhering matrices, and render the masses soft enough to be easily broken into fragments of a convenient size for melting. After the mineral is duly prepared, it must be smelted in furnaces of large capacities, from 16 to 25 *feet* high, and from 10 to 14 wide: the most approved shape nearly resembles that of a hen's egg, with the largest end undermost, below which is a square cavity to contain the melted metal, and at the top a very short vent about 20 *inches* in diameter. The inner wall is built of fire stone, which endures very strong heat with little risk of melting, and all the joints are cemented with mortar composed of sand and clay. This is surrounded with more building, which deviates more and more from a circular form, and becomes a square building of about 20 feet at the base, and gradually converges to the top.

6. Near the bottom is an aperture, for the insertion of the pipe of a large bellows, worked by water, or by other machines that may produce a strong current of air. Some very powerful ones I have seen in the iron works at *Colebrook dale*, and consist of two iron cylinders, about two or more feet wide, whose pistons are alternately moved by a small fire engine; but Mr. Wilkinson very ingeniously adapted to his

own,

With respect to the œconomical effects, iron is divided into *cold-short*, *red-short*, and *tough*; and the ores into *refractory*, *fusible*, and those that do not want any admixture; which depends

own, a large vaulted receiver surrounded by water, which produces a very regular and uniform blast. Two or more holes are also left ready to be occasionally opened at the bottom of the furnace, to permit, at a proper time, the scoria and the metal to flow out, as the process may require. Charcoal, or coke with lighted brushwood, is first thrown in: and when the inside of the furnace has acquired a strong ignition, the ore is thrown in by small quantities at a time, with more of the fuel; and commonly a portion of lime-stone is thrown also, as a flux. The ore gradually subsides into the hottest part of the furnace, where it becomes fused; and the metallic parts, being revived by the coal, pass through the scoria, and fall to the lower part, or bottom of the furnace, where a passage is open for taking off the scum or dross. The metal now, in strong fusion, is let out, by a tap-hole, into furrows made in a bed of sand: the large mass, which sets in the main furrow, is called by the workmen a *sow*, and the lesser ones *pigs* of iron. *Chimney-backs*, *stoves*, *garden-rollers*, &c. are formed of this rough metal, taken out of the receiver with ladles, and cast into moulds made of fine sand.

7. The quantity of fuel, the additions, and the heat, must be regulated, in order to obtain iron of good quality; and this quality must likewise, in the first product, be necessarily different, according to the nature of the parts that compose the ore.

8. Two or 3 *tons*, *viz.* 4, or 6,000 pounds weight of iron, are now run off in 24 hours, at some large furnaces, after the application of the large bellows; whilst scarcely an hundred weight could be obtained in a day before that application, because a large quantity of the metal was left in the dross; hence, in some places, the slags of different ores, left by old operators in former times, are now re-melted to advantage along with fresh ore; and, on account of the richness of these old slags of different ores, some people have been misled

pends on accidental circumstances, and the method of working.

Although iron is commonly mixed in the different kinds of earths; yet it cannot be asserted

misled into the opinion, that the metal was regenerated in them.

9. Peat and turf has been found to answer tolerably well, mixed with charcoal, for the smelting of iron-ores; but I am informed, that the attempt I mentioned of its use at p. 485, has at last been found not to answer the expectations that had been conceived from the first trials. *Pit-coal*, if applied to the same purpose, renders the *iron* hard and brittle; but this inconvenience is prevented, by previously coaking the coal, and employing it in the state of true *coak*. Cramer, in his *Art of Assaying*, p. 347. says, that *pit-coals*, *kennel-coals*, and *Scotch-coals*, *which burn to a white-ash like wood*, and abound more in bitumen, may be used in the first fluxion of the iron from its ore; and if the iron proves not so malleable as required, this property may be given to it, by melting the metal a second time with wood.

10. The best *cast-iron*, or *raw-iron*, as much freed from heterogeneous matters, as the usual process of smelting can effect it, is not at all malleable, and so hard as perfectly to withstand the file.

11. In general the impure cast iron, as run from the ore, is melted down a second time in another furnace, intermixt with charcoal. A strong blast of air being impelled on the surface of the metal, its fusion is remarkably promoted; the iron thickens into a mass called a *loop*, which is conveyed under a large hammer raised by the motion of a water-wheel. The iron is there beaten into a thick square form, is then heated again until almost ready to melt; and is forged: by a few repetitions of this process, it becomes compleatly *malleable*, and is at length formed into bars for sale.

12. Iron in this state of *malleability*, is much softer than before, and of a fibrous texture. But if it is still crude and brittle, after the above process, it shews that there have remained heterogeneous matters, being hidden in its interstices, which must be expelled; for this purpose the iron must be stratified

serted with Becher, that iron may be melted out of every earth, by adding only a phlogiston; since in that case this metal might also be got out of *Muscovy* glass, *pure quartz*, *chalk*, *white*

stratified with charcoal-dust within a proper furnace, heaped up in good quantity in *strata*; then the fire must be blown pretty strongly, so as to bring it to a fusion, which is to be helped by the addition of fusible scorias, or of sand. The fire must not be much greater than necessary to make all these melt as equally as possible; to obtain this end, the melted mass must be agitated here and there with poking rods of wrought iron, in order to make every part feel alike the action of the fire and air; and the increasing scorias taken out once or twice.

13. In the mean time a great many sparkles will be thrown out from the iron, which diminish the more as the iron comes nearer to the desired degree of purity, but they never cease entirely. The burning coals being then removed, and the scoria conveyed out of the fire, through a channel made for that purpose; the iron, by lessening the violence of the fire, grows solid, and must be taken out red-hot, and tried by striking it with a hammer. If it proves crude still, let the melting be repeated; and when it is at last sufficiently purified, it is to be hammered, and extended various ways, by making it red-hot many times over; this done, it will no longer be brittle, even when cold, as Cramer asserts.

14. Cast iron has of late been brought into the malleable state, by passing it through rollers, instead of forging it. Indeed this seems to be a real improvement in the process, as well in point of dispatch, as in its not requiring that skill and dexterity, which forge-men only acquire by long practice. If the purposes of commerce should require more iron to be made, it will be easy to fabricate and erect rolling machines, though it might be impracticable to procure expert forge-men in a short time.

13. This method was discovered by Henry Cort of Gosport, who obtained an exclusive privilege, granted by the king's patent. By this process the raw or cast-iron is freed from

white transparent fluor, &c. which probably has never yet been done.

Nature has bestowed on Sweden an immense store of iron ores; so that whole mountains, in Tornea and Lappmark in Lapland, consist solely of a pure, and a very rich iron-ore.

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from the impurities, which are not discharged in the common methods of rendering this metal malleable; for iron is in itself a simple homogeneous metal; and all iron must become equally good, if it be purified from the heterogeneous and unmetallic particles that are any ways mixed with it.

16. The ordinary method of converting *cast iron* into *malleable*, is, as have been seen, by employing great quantities of charcoal, which furnishes phlogiston, and remetallizes the particles, which are unmetallized, and mixed with the heterogeneous matters contained in the fused mass: but in Cort's method there is no need of charcoal, instead of which, only sea-coal is employed; because the object is not to remetallize, but only to expell what is unmetallic; instead of endeavouring to restore the calcined parts with charcoal at a great expence, and still leaving the business undone.

a. The iron is only heated and wrought simply by the heat of the flame, instead of being mixed with the burning fuel and ashes, which are not easily disengaged afterwards from the metal.

b. The method of squeezing it between the rollers, forces out the melted slags from the metallic pores, and brings its metallic fibres into a perfect solidity, and close contact, so that they are obliged to cohere much more perfectly to each other, than by the interrupted and partial action of the hammer.

d. By the operation of being long stirred, the sulphureous particles are more disposed to be disengaged, and are burned away in the form of blue sparks; the metal then begins to curdle, and to lose its fusibility, like solder when it just begins to settle; the metallic particles meeting and coalescing together, much like the churning of milk, where the cream is separated by the union formed between the ore. Large veins of the same ore are likewise found, in almost every province of that kingdom, of such a nature, that few countries can produce better or richer.

The magnetical power, with respect to its principles and origin, is no better understood than

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the fibrous particles of the cheese. The curdles formed into a connected mass become what is called *loops*. The process is as follows:

17. Five or 6 hundred weight of raw, *cast-iron* (and even of *cold-short* iron), is brought into a low fusion, on a kind of hearth, or low furnace, in which it lyes to the depth of about 6 *inches*. One or two workmen continually stir this fused mass, with long iron pokers, for about 4 or 5 hours. The heat is then lowered: the men fashion the iron into narrow pieces of about 3 ½ *feet* long, and 3 *inches* square, with long knives or chisels made for that purpose. They are then heated to the welding degree, and hammered to expel and scatter the unmetallic dross. These slabs are then formed to a wedge point at one end, in order to adapt them to be received between the rollers: they are malleable already, but they contain still some dross.

18. They are then heated again to the hotest welding heat in the air furnace: and immediately passed through large iron-rollers, turned by a water-wheel, or by horses. If the end presented to the rollers should slip, instead of entering, a boy who stands ready, throws some sand upon the iron, and it goes in easily. Much foreign and heterogeneous matter is squeezed out by the rollers; and the iron comes out in a purer malleable state. The same heat will serve to pass the iron through two setts of rollers, which are groved so as to fashion it into *nail-rods*, or other *forms*, according to the required purposes.

19. Various and repeated severe trials have been made in the Royal dock-yards of England, as I have been informed, in the presence of persons of knowledge and rank, to prove the *strength*, *malleability*, and *softness*, or *toughness* of this new

than electricity, yet something more with respect to its effects. Though both these qualities are now considered as different powers, they may perhaps in time be regarded as something nearer allied to each other.

The

new iron; and it has proved to be equal, and even sometimes superior to the best Swedish iron. But I cannot conceive, indeed, by what singular fatality so great an improvement in manufacturing this most useful metal, has not yet been generally adopted by our English iron-masters.

20. *Steel* is iron in an intermediate state, between cast-iron and malleable iron, which is soft and tough. The iron, run from some German ores, is found to be a good steel, when forged only to a certain point.

But the best steel is usually made by cementation from the best forged iron, with matters chiefly of the inflammable kind. Two parts of pounded charcoal, and one of wood ashes, is esteemed a good cement. The charcoal dust may be made of *bones*, *horns*, *leather*, and *hairs* of animals, or of any of these ingredients, after they are burned in a close vessel, till they are black; these being pulverized, and mixed with wood-ashes, must be well mixed together. The iron bars should be of pure metal, not over thick, and quite free from heterogeneous matters: their flexibility, both when hot and when cold, is a very good sign thereof. A deep crucible, two or three inches higher than the bars, is to receive part of the cement, well pressed at the bottom, to the height of $1\frac{1}{2}$ inch; and the bars are to be placed perpendicularly, about one inch distant from the sides of the vessel, and from each other. All the interstices are to be filled with the same cement, and the whole convered to the top with it; then a tile is applied to cover the vessel, stopping the joints with thin lute.

21. The crucible is then to be put in the furnace, and a strong fire is to be made that it be kept moderately red hot for 6 or 10 hours together; at the end of which time they will be found converted into steel. If the cementation be continued too long, the steel will become excessively brittle, incapable of being welded, and apt to crack and fly in forging,

The magnetical power is not innate in the iron, but is collected into it by degrees, as is verified by experiments; it may be expelled, it may vanish, and become collected again, as it

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forging. On the contrary, steel cemented with absorbent earths is reduced to the state of forged iron.

22. Steel is further purified, for making the nicest kinds of instruments, such as *lancets*, *pen-knives*, *razors*, and *various pieces*, for the best kind of *watches*, *time-keepers*, or *chronometers*, and *Astronomical regulators*. This purification of steel, consists in melting it again with a strong, but regular, fire in a crucible, the better to free it from the heterogeneous parts, and little flaws, that may be contained in it. It is then called *cast-steel*, when fused into bars: which name, however, does not imply that the pieces, for instance the *cast-steel razors*, have been really cast in their present shape; for they must be forged from the bar, after it is cast. The fusion must have been perfect, so that the metallic parts be rendered uniform. The metal diminishes a little by this process, for a bar of common steel 36 inches long, will afterwards produce another only of 35; if properly fused and purified.

23. The *cast-steel* will not bear more than a *red heat*; otherwise it runs away, like sand under the hammer, if the heat is pushed to the *welding degree*. Dr. Watson says, that this manufacture of cast steel was introduced at Sheffield only about 40 years ago, by one Waller. I knew this man, who was still living about the year 1765; he dwelled at St. Bartholomew's close, and was a galloon-wire drawer by trade. The difficulty of procuring small cylinders of good steel, to flatten the wire for lace-work in his business, whose defect proceeded from the bad texture of the steel, set his imagination on the enquiry after a method of purifying the metal to a greater perfection: and he thought that a new fusion of it was the most likely to accomplish his views. After some trials, he at last succeeded; but it was soon known to others, who got the advantages for themselves, of which ill fate the real inventor very bitterly complained till the end of his life. His own name was even forgotten, as one Huntsman practised this art to such an extent, that *cast steel* was known under his sole name afterwards.

24. But

it were out of the air: ſince the natural load-ſtones for the moſt part occur in ſmall veins to the day, whereas at a greater depth only re-fractory

24. But before this diſcovery, made by Waller in England, this kind of ſteel was made already in Germany, as Watſon aſſerts; and from thence ſome ſmall quantities were brought to England at a conſiderable price. Since that time this branch of buſineſs is carried on advantageouſly at Sheffield; for the manufactures there furniſh a great abundance of broken tools and old bits of ſteel, at *a penny* a pound, which, after fuſion and purification, ſell for 10 or 12 times as much.

25. It is a valuable property of iron, after it is reduced into the ſtate of ſteel, that though it is ſufficiently ſoft when hot or when gradually cooled, to be formed without difficulty into various tools and utenſils; yet it may be afterwards rendered more or leſs hard, even to an extreme degree, by ſimply plunging it, when red-hot, into cold water. This is called *tempering*. The hardneſs produced is greater in proportion, as the ſteel is hotter, and the water colder. Hence ariſes the ſuperiority of this metal for making mechanic inſtruments or tools, by which all other metals, and even itſelf, are *filed*, *drilled*, and *cut*. The various degrees of hardneſs given to iron, depend on the quantity of ignition it poſſeſſes at the moment of being tempered, which is manifeſted by the ſucceſſion of colours, exhibited on the ſurface of the metal, in the progreſs of its receiving the increaſing heat. They are the *yellowiſh-white*, *yellow*, *gold-colour*, *purple*, *violet*, *deep-blue*, and *yellowiſh-white*; after which, the compleat ignition takes place. They proceed from a kind of ſcorification on the ſurface of the heated metal.

26. A bar of clean white ſteel may be made to aſſume all the above colours at once, by placing one end in the fire, and keeping the other end out, which is ſuppoſed of a proper length to remain cold.

27. Theſe colours ſerve as ſigns to direct the artiſt in tempering this metal. For though ignited ſteel, ſuddenly quenched in very cold water, proves exceſſively *hard* and *brittle*; yet it may be reduced to the required degree of temper, by heating

 it,

fractory iron-ores are found. There is the same difference between an artificial magnet of Dr. Knight's, and a bar of steel, whether of the

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it, till it exhibits a known colour. This is the method employed in this process by the artists. As soon as the piece of steel is compleatly ignited, they plunge it in a very cold water; and as soon as it looses its fiery appearance, they take it out, rub it quickly with a file, or on a plate covered with sand, that it may have a white surface. The heat, which is still within the metal, soon begins to produce the succession of colours. If a hard temper is desired, as soon as the *yellow tinge* appears, the piece is dipped again, and stirred about the cold water. If the *purple* appears before the dipping it, the temper will be fit for tools employed in working upon metals; if dipped while *blue*, it will be proper for springs, and for other instruments fit to cut all sorts of soft substances; but, if the last *pale colour* be waited for, the steel will not be hard at all.

29. This process shews, that the minutest particles of the metal are hurried by the fire into a violent motion among themselves; and, if the heat be suddenly checked, they remain forcibly stretched against each other, and retained out of their natural position; of course, they are prevented from receeding or sliding to another point of mutual contact, neither can the metallic texture be then allowed to adapt itself to another shape or position, and receive a new form. On this account, almost all soft metals, if capable of being well hammered, do not fail of becoming harder and stiffer after the operation; and their specific gravities are accordingly increased, because the same quantity of matter is then compressed into a lesser volume; whilst it is well known, that hard-steel is specifically lighter than after it has been hammered, *viz.* in the proportion of 7,704 to 7,195, according to Musschenbroek.

30. It deserves notice, that a piece of iron is rendered considerably warm by hammering, so as to even become red hot. It seems that phlogiston is thereby squeezed out of the metal, and is immediately attracted or absorbed by the surrounding air, to which it has the greatest affinity; and being deprived of its own specific heat; this last becomes *sensible* on the metal. But after the iron has been compleatly

6 hammered

the same shape or not, as between a natural loadstone; and a blackish blue iron-ore; whence it is ridiculous to insist with a certain author, that

hammered once, it is asserted, that it cannot be rendered again *red hot* by the same operation, because no further compression can then be made.

31. Hard steel is the only metal that, being struck slantwise with the sharp edge of a flint, or of another hard stone, produces sparks of fire. The minute particles of the metal are driven off with extreme rapidity, their phlogiston is set loose, instantly attracted by the air, whose *specific heat*, or *fire*, rushes into the metallic particles, inflames, and burns them; and they become truly calcined into scoria, as may be seen when examined with a magnifier; for they are mostly, as little hollow balls, about one hundredth of an inch in diameter, of black or greyish colours, like the cinders of a black-smith's forge.

32. The theoretic solution of the two last phænomena have been lately rejected by the *modern aerial, French Philosophers*, who absolutely deny the very existence of what has been called *phlogiston* since the time of Stahl; but, until they can give a more intelligible and a better grounded etiology of these facts, by the evident properties of *their airs*, every philosopher remains at liberty to disregard their opposition.

33. P. S. I had forgot to observe upon the text *l*, p. 719. that iron is often manufactured so as to be 150 times, and even above 630 times more valuable than gold. I lately weighed some common watch *pendulum-springs* at Mr. Tho. Wright's watch-maker to the King, such as are sold at *half a crown* by the London artists for common work; and ten of them weighed but *one* single grain. Hence *one* pound avoirdupois ($=7000$ gr.) contains *ten times* as many of these springs; which, at half a crown apiece, amount to 8750 *pounds sterl.* The troy ounce of gold sells at 4 pounds sterling, and the pound ($=5760$ gr.) at 48 pounds sterl. which gives 58,33 (or 58 pounds 6 shillings and 7 pence) for each pound *avoirdupois* of gold: and of course $\frac{8750}{58,33}=150$.

34. But the *pendulum-springs* of the best kind of watches, sell at *half a guinea* each: and at this rate, the above mentioned value must be increased in the ratio of 1. to 4,2: viz. of

that no iron-ore can be attracted by the load-ſtone, but what of itſelf contains ſome magnetical virtue.

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of *half a crown*, to *half a guinea*: which will amount to 36750 pounds ſterling; and this ſum, divided by the value of this *pound* of gold, gives above 630 to the quotient.

35. N.B. 2. I ſhould have noticed alſo at p. 750, that the attraction between the *iron* and the *load ſtone* is the ſureſt teſt to diſcover the preſence of this metal in any ore whatever; for there is not any other body but iron, that is attracted by the natural load-ſtone, or by the artificial magnet, which has the very ſame property, and is compoſed of hard ſteel, properly impregnated with the magnetic power.

36. But very few iron-ores are really attracted by the load-ſtone, before they have been made *red-hot*, as Cramer aſſerts. He directs, for this purpoſe, to reduce into powder the ore that is to be tried, by pounding it in a *braſs-mortar*, but never in an *iron-one*: the powder is to be put in a crucible, well covered and luted, adding to the powder a ſmall quantity of tallow: then being placed in a furnace, let it be made red-hot, for about one hour, in a ſtrong fire. When cold, the powder is to be extended upon a ſheet of ſmooth paper, and applying very near to it the load-ſtone, or the magnet; if there are any particles of iron, they will be attracted by, and will ſtick to it.

37. It is remarkable that iron, even adulterated with other metals, or ſemi-metals, without excepting arſenic, is not thereby rendered altogether unfit to be attracted by the natural or artificial load-ſtone; although the power of being attracted is leſſened, but not extinguiſhed, in proportion to the quantity of the extraneous matters.

38. Antimony however is the only metallic body, that can prevent this attractive force between iron and the load ſtone, as the ſame author remarks. (N° 360 of *Art of Eſſaying Metals*: p. 141.) He adds alſo that *ſulphur* ſcarcely prevents the ſame attraction: but Maquer ſays poſitively, that ſulphur is alſo a ſubſtance, that can hinder the reduced iron from being attracted by the load-ſtone. *See the article* Molybdene *in his* Chemical Dictionary. It is rather odd, that ſo little notice has been taken by other mineralogical writers and philoſophers, of the action of theſe two ſubſtances on this general property of iron! *The Editor, from Bergman, &c.*

ORDER

ORDER THE THIRD.

Semi-metals.

SECT. 348. (221.)

Bismuth, Tin-glass. *Bismuthum, Marcasita officinalis*, Lat. *Askbly*, Swed. *Wismuth*, Germ.

This semi-metal is [a],

a. Of a whitish yellow colour.

b. Of

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[a] Bismuth, or vismuth, is the heaviest of all the brittle metals, called semi-metals.

Its specific gravity, according to Kirwan, is from 9,600 to 9,7000.

Nitrous acid, and *aqua regia*, dissolve it perfectly.

The *vitriolic* acid must be boiled nearly to dryness, before it acts upon this semimetal: and

The *muriatic* acid only attacks its calx.

The quantity of phlogiston, which resists the action of menstrua on it, is expressed by 57; and its power of retaining it, ranks it in the *seventh* place.

It melts at the heat of 494 degrees. *Bergman.*

Its solution by nitrous acid is crystallisable, into quadrilateral pyramids. *Wallerius.*

The addition of pure water to the nitrous solution of bismuth, precipitates its calx, and is the criterion by which this semimetal is distinguished from all other metals.

This white calx, called *Magistery of Bismuth*, is used by the fair sex, as a paint to whiten the skin, and improve the complexion; which, however, it gradually impairs

 very

b. Of a laminated texture, yielding under the hammer, and neverthelefs very brittle.

c. Its fpecific gravity to water is, as 9,700 :: 1000.

d. It is very fufible, calcines and fcorifies like lead, if not rather eafier, and therefore it works on the cuppel. It is confiderably volatile in the fire.

e. Its glafs or flag becomes yellowifh brown, and has the quality of retaining fome part of the gold, if that metal has been melted, calcined, and vitrified with it.

f. It may be mixed with the other metals, except cobalt and zink, making them white and brittle,

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very remarkably. Strong fmells, fulphureous vapours, and very odorous emanations, immediately turn this cofmetic into a brown or black colour.

The magiftery of bifmuth appears to have indeed fome latent corrofive quality; and, when freely ufed as a cofmetic, muft be very hurtful. It gradually impairs the natural complexion; and leaves, for old age, a coarfe, difagreeable, and ugly fkin.

It is faid that this magiftery produces a whitenefs in *grey*, *reddifh*, *yellow*, or *other coloured* hair; but the contrary is evinced by experiment; for it changes the whiteft flaxen hair firft to a *yellowifh*, then to a *yellowifh*-brown, afterwards to a *dark-brown*, and at laft to a *blackifh colour*.

The tryal may be made in two ways; by boiling the hair in water, along with the magiftery; or by applying the magiftery mixed with pomatum, or hanging the hair in the fun greefed with it. The oftener this is repeated, the darker will the colour be. We may therefore judge from hence, that this magiftery is lefs fit for the purpofe of cofmetic, than any other, that ever was recommended to the fair fex.

Moft

g. It is soluble in aqua-fortis, without imparting to it any colour; but to the aqua-regia it gives a red colour, and may be precipitated out of both these solutions with pure water, into a white-powder, which is called *Spanish white.* It is also precipitated by the acid of sea-salt, which last unites with it, and makes the *Vismutum corneum.*

h. It amalgamates easily with quicksilver. Other metals are so far attenuated by the bismuth, when mixed with it, as to be strained or forced along with the quicksilver through skins or leather.

SECT. 349. (222.)

Native Bismuth.

Bismuth is found in the earth.

A. Native, *Vismutum Nativum* [b].

Most metallic substances unite with bismuth, and are rendered more fusible by its addition.

It is used in making *pewter*, *printers types*, *solder*, &c.

The great fusibility of the mixture of bismuth, tin, and lead, renders it of a great use in making collars for the axles of some mechanical instruments to run in. *The Editor from* Neumann, Nicholson, &c.

[b] This is the most common of all native metallic substances; and is generally found either in cubes, or octagons; or of a dendritical form; or in that of thin laminæ, investing the ores of other metals, particularly those of Cobalt; from which is easily distinguished and separated by its great fusibility.

It is said to be sometimes found alloyed with silver. In such case it may be easily separated by its solution in nitrous

 acid;

This resembles a regulus of bismuth, but consists of smaller scales or plates.

1. Superficial, or in crusts.

2. Solid, and composed of small cubes.

This is found in, and with, the cobalt ore, at Schneeberg in Saxony, and other foreign places: Likewise along with the copper ore, at Nyberget in the parish of Stora Skedwi, in the province of Dalarne.

SECT. 350. (223.)

Bismuth Calciform.

B. In form of calx, *Visმutum calciforme*.

1. Powdry or friable, *Ochra visimuti*.

This is of a whitish yellow colour: it is found in form of an efflorescence, to the day, at Los, in the province of Helsingland.

It has been customary to give the name of *Flowers of Bismuth* to the pale red calx of *cobalt*, but it is wrong; because neither the calx of bismuth, nor its solutions, become red, this being a quality belonging to the *cobalt* [c].

I have

acid; for, by the addition of water, the bismuth only will be separated, and any other metal will remain in the solution.

Native bismuth is of a yellowish white colour; and so fusible as to melt at the flame of a candle, when pure. *The Editor from* Kirwan *and* Wallerius.

[c] There are *greenish-yellow* calces of bismuth, frequently found with glittering particles, interspersed through stones of various

I have seen a radiated cristallisation of a metallic appearance, which was found at Schneeberg, and was likewise called *Bismuth Flowers*; but in the small trial I was permitted to make on it, it did not discover the least marks of bismuth, but answered rather to *zink*, if *zink* may be supposed to exist in a native state.

SECT. 351. (Additional.)

Bismuth mineralized by vitriolic acid.

This ore is called *Wismuth Bluth* by the Germans. It is said to be of a yellowish, reddish, or variegated colour; and to be found mixed with the calx of bismuth, incrusting other ores. From *Kirwan*, p. 334.

SECT. 352. (224.)

(Mineralised Bismuth, *Vismutum sulphure mineralisatum* [d].

This is, with respect to colour and appearance, like the coarse tessellated potter's lead ore;

various kinds; silver, and other metals, are also found in this kind of ore: from all which it is separable by solution in *nitrous acid*, as has been said in note [a] to p. 759. Kirwan, p. 333.

[d] This is chiefly found in Sweden; is of a bluish grey colour, of a lamellar texture, and tessellar form like galena; but much heavier,

It

ore; but it consists of very thin square plates or flakes, from which it receives a radiated appearance, when broken crosswise.

1. With sulphur, *Visimutum sulphure mineralisatum.*

a. With large plates or flakes, from Bastnas at Riddarshyttan, Basringe and Stripas in Westmanland.

b. With fine or small scales, from Jacobsgrufvan at Riddarshyttan, and the mines at Los, in the parish of Farila, in Helsingland.

SECT. 353. (225.)

2. *Visimutum ferro sulphurato mineralisatum.*

2. With sulphurated iron.

a. Of coarse, wedge-like scales, from Kongruben, at Gellebeck in Norway [*e*].

It sometimes presents parallel striæ like antimony; and its colour is variegated. It is said to contain also *cobalt* and arsenic.

This ore is very fusible; the sulphur mostly separates in scorification; and it is soluble in nitrous acid. *From* Kirwan *p.* 334.

[*e*] This mineralised bismuth ore yields a fine radiated regulus; for which reason it has been ranked among the antimonial ores, by those who have not taken proper care to melt a pure regulus, or destitute of sulphur, from it; while others, who make no difference between regules and pure metals, have still more positively asserted it to be only an antimonial ore. *The Author.*

In Schneeberg they have what is called *columbine* bismuth, and *plumose* bismuth; the former has its name from its color, the

SECT. 354. (Additional.)

Mineralised with Sulphur and Arsenic.

This ore of bismuth is of a whitish-yellow, or ash-colour [*f*]:

Has a shining appearance, and

Is composed of small scales or plates, intermixed very small yellow flakes.

It is of a hard and solid texture;

Sometimes strikes fire with hard steel.

Has a disagreable smell, when rubbed.

Does not effervesce with *aqua fortis:*

But is partially dissolved by the same acid.

This solution, being diluted with water, becomes a kind of sympathetic ink; as the words

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the latter from the texture. The latter is said to contain a great qantity of cobalt. *Brunnich.*

In the *dry way* this ore is extracted from its stony bed, by mixing 2 parts of the pulverized ore with one of pounded glass, and one of calcined borax, melting the whole in a crucible lined with charcoal. *Kirwan*, p. 335.

[*f*] 1. There is also a grey bismuth-ore, of the arsenicated kind, with a striated form, found at Helsingland in Sweden, and at *Annaberg* in Saxony.

2. Another ore of bismuth of the same kind, with variegated colours of *red*, *blue*, and yellow *grey*, is also found at *Schneeberg* in Saxony.

3. Striated with green fibres like an *Amianthus*, at Misnia in Germany, and at *Gillebeck* in Norway.

4. With yellow-red shining particles, called *Mines de Bismuth Tigrées* in French, at *Georgenstadt* in Germany, and at *Annaberg* in Saxony.

5. The *minera Bismuthi arenacea*, mentioned by Wallerius and Bomare, belongs also to the same kind of the arsenicated ores. *The Editor, chiefly from* Bomare.

written

written with it on a white paper, and dried, are not distinguished by the eye; but, on being heated before the fire, they assume a yellowish-colour. This ore is found at *Rappolt*, and *Schneeberg* in Saxony. *Wallerius* and *Bomare*.

SECT. 355. (226.)

Observations on Bismuth [g].

Although Mr. Pott has, in a separate Treatise on bismuth, shewn, that it is dissolved without giving

[g] Bismuth, or tin-glass, in its external appearance, has a great resemblance to *regulus of antimony* and *zinc*, differing little otherwise, than in the largeness of its plates or scales; and its contracting a yellowish cast on the surface, when exposed to the air. But as to its intrinsic properties, it is extremely different; melting far more easily, not evaporating so readily, being differently acted upon by acids, producing different effects upon other metallic bodies, &c.

When bismuth is kept in fusion, and is stirred, it soon calcines, gaining at the same time an increase in its weight of near half an ounce upon a pound.

The calx melts, on raising the fire a little, into a brownish or yellowish glass, which promotes the vitrification of earths, and of the refractory metallic calces more powerfully: and corrodes and sinks through common crucibles more readily, than glass of lead itself.

If bismuth be mixed with gold or silver, a heat, that is but just sufficient to melt the mixture, will presently vitrify a part of the bismuth, which having no action on these perfect metals, separates and glazes the crucible all round.

It

giving any colour to the solution, and that it is precipitated with pure water; and, though the mine-master Mr. Brandt has likewise, in the *Acta Upsaliensia* for the year 1735, given an accurate history of the cobalt; we find nevertheless in some new authors such a definition of bismuth, as includes at the same time the principal characters of the cobalt, viz.

It melts a little later than tin; and seems to be the most fluid of all metallic substances.

When in fusion it occupies less volume than in its solid state; a property peculiar to iron among metals, and itself among the semimetals.

It emits fumes in the fire as long as it preserves its metallic form. When calcined, or vitrified, it proves perfectly fixed.

Calx of bismuth, long reverberated, does not, as some pretend, become *red* like the calces of lead. It scarcely retains even the form of a calx; for a part of the bismuth is soon revived into its metallic appearance by the flame. None of the destructible metallic bodies is so easy of revival as this semimetal. If the vessel be covered, and all inflamable matters excluded, vitrification is the only change that ensues.

Bismuth cemented with sulphur, readily unites with it, and melts easier than by itself; but on continuing the fire, they soon separate again, the bismuth falling to the bottom, and a sulphureous scoria swiming on the surface.

Calx of bismuth likewise, very easily absorbs sulphur, and forms with it a curious needle-form mass, exactly resembling antimony, contracting a reddish tinge externally on exposure to the air. The quantity of sulphur imbibed is less than half the weight of the calx; a part of the sulphur having sublimed, when the operation was performed in a retort, in that proportion.

Silver added to this concrete, melts with it in a very gentle heat, into a brittle regulus. Gold also unites with it, but requires a much stronger fire: the compound is brittle, in appearance like an ore, with here and there some striæ or shining particles.

Copper

that of giving to glafs a blue colour, and to tinge folutions red. This confufion proceeds from the bifmuth being commonly found among cobalt ores, and not being feparated from it but by the way of eliquation; during which the cobalt, as being lefs fufible, remains, and is by the workmen called *Vifmut graupe*, or Bifmuth grains.

This

Copper melts with it in a fmall heat, with remarkable facility; and after they have been united, the compound continues to retain its extraordinary fufibility. On the addition of lead to this compound, a new combination takes place; the copper and fulphur arife to the furface in fcoria refembling an ore, whilft the bifmuth and lead form a regulus at the bottom.

Zinc and bifmuth do not unite together, the zinc flowing diftinct upon the furface, and burning as it does by itfelf.

Mercury forms with bifmuth an amalgam, which readily adheres to iron. If the iron, coated with the amalgam, be expofed to the fire, the mercury exhales, and greateft part of the bifmuth remains fixed upon the iron, which then looks as if it had been filvered.

If mixtures of bifmuth, with fome other metals, particularly lead, be amalgamated, the lead is found to be fo attenuated, as to pafs with the quickfilver through leather. On ftanding, the bifmuth is thrown up to the furface in form of a dark-coloured powder, the lead remaining diffolved in the quickfilver.

Equal parts of lead, tin, and bifmuth, form a blackifh fparkling compound, refembling the fmall-diced ores of lead.

The fpecific gravity of a mixture of bifmuth and copper, is exactly the mean gravity of that of the two ingredients unmixed. But mixtures of it with iron are fpecifically lighter than the ingredients feparately: whilft mixtures of bifmuth with gold, filver, tin, lead, and regulus of antimony, are heavier than before by themfelves feparately.

Tin being too foft of itfelf for making veffels and utenfils for common ufe, is generally worked with fome additional metallic

This error is excusable in those who do not pretend to maintain and vindicate their ignorance, it having been the fate of the semi-metals to be but very little examined. If the alchemists had not thought the quicksilver, antimony, and zink, fit for their purposes, we should very likely have still wanted many of those

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metallic matters, of which bismuth is one of the principal. This mixed metal is called *pewter* in England, and constantly mistaken abroad for pure tin, being called by the name of this last metal. *See the* note N° 9 *to page* 643.

Bismuth being easier to fuse than lead or tin, is mixed with both to make a proper solder for each.

This semi-metal being reduced to powder, and applied, with the white of eggs, upon turned wood, makes it look as silvered, after it is dryed, and properly rubbed over with a hard polisher.

Bismuth is preferable to lead for purifying gold and silver by cupellation, scorification, &c. For it more effectually promotes the destruction of the imperfect metals, and the vitrification of the earths, calces, or any refractory matters blended with them; as it procures a greater tenuity in the fusion, than lead is capable of producing. In all the operations of this kind, where sulphur makes one of the heterogeneous matters, bismuth is of the greatest advantage; namely, on account of its forming with that concrete an extremely fusible mass, whilst lead combined with sulphur, proves extremely refractory.

Bismuth has been too often employed for the adulteration of quicksilver, as rendering a very considerable proportion of lead intimately united with it. One part of this last metal, mixed with an equal one of bismuth, may be incorporated with three of quicksilver, without affecting its fluidity. Quicksilver thus adulterated is not only unfit for medicinal uses, but even for the common mechanic purposes of gilding and silvering; as the workmen find in this case, that it leaves upon the gold or silver a livid leaden hue, which spoils the proper fine appearance of the work.

those advantages which they afford both in medicine and common life.

Bismuth, it is true, has likewise in its time been in some favour with adepts; but it soon lost its credit: and was left to those who contented themselves with less prospects than

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work If the abuse is discovered, the mercury may be purified by distillation; although it appears by the assertions of Boerhaave, that a very slight film is always acquired by the process. *See the Note to p. 592.*

Some say that the bismuth earth, or *caput mortuum* of bismuth, may be employed for making blue glass, in the same manner, as calcined cobalt; but when this happens, it only proceeds from the accidental mixture of cobalt, which is sometimes found naturally in the ores of bismuth.

A tincture is drawn from the ore of bismuth dissolved in *aqua fortis*, which being mixed with a saturated solution of sea-salt, and inspissated, yields a reddish salt: its watery solution is the curious liquor, called the *Green Sympathetic Ink*, though there is a real impropriety in calling it *green*, where it is in fact a *red liquor*. If any words are written with this ink on white paper, the characters disappear as soon as they are dry; but on holding the paper to the fire, they become *green* and legible; on cooling they disappear again, and this repeatedly any number of times.

According to Bomare, the words written with this sympathetic ink may also be rendered legible, by wetting them with a spunge or pencil dipped in an aqueous solution of hepar sulphuris.

The experiments succeed best, when the tincture, drawn from the calcined ore of bismuth, is mixed with a solution of one fourth of its weight of sea-salt; this mixture is then evaporated almost to dryness, and the residuum is dissolved in water, which is then the sympathetic ink. If the tincture be mixed with nitre or borax, instead of sea salt, the characters will become *rose coloured* when warmed; and if sea-salt is afterwards passed over them, they will become *blue*; but if mixed with alkali sufficient to saturate the acid, they change to *purple* and *red* colour by heat.

Bismuth

than of making gold and the universal medicine; as to pewterers, tin-workers, and other tradesmen, who find their advantage in the fusibility of this semi-metal, and its giving colour and hardness to tin and lead.

SECT. 356. (227.)

3. Zinc, Spelter. *Zincum*, *Marchasita aurea*, *Zinethum*, Lat. *Spiauter*, Swed.

General properties of Zink.

This semimetal is distinguished from other metallic substances by the following qualities;

a. Its colour comes nearest to that of lead, but it does not so easily tarnish [*a*].

It

Bismuth is most commonly lodged in cobalt-ores; and, when they are of a *high red*, or *peach-bloom* colour, they are called *Bismuth bloom*, or *Flowers of Bismuth*. It was formerly believed, and some are still of opinion, that *Bismuth* gives to glass the same *blue-colour* as the cobalt does; because the dross which remains after the *Bismuth* has been melted out, called *Bismuth-grain* by the smelters, produces sometimes that effect. But, as no such grains or colouring earth remain from pure bismuth, it is plain that this quality must arise from something that was mixed with the bismuth, which undoubtedly is nothing else but some partial mixture of the cobalt ore, that was contained along with the bismuth. *Gellert's Metal. Chem.* pag. 61. *The Editor, chiefly from* Neumann, Lewis, &c.

[*a*] Zinc is the most malleable of all the semi-metals.

Its specific gravity is = 6862, according to Bergman; and Kirwan asserts it to to be from 6,900 to 7,240.

b. It ſhews a texture, when it is broken, as if it were compounded of flat pyramids.

c. Its ſpecific gravity to water is, as 6,000 or 7000 : : 1000.

d. It melts in the fire before it has acquired a glowing heat; but when it has gained that degree of heat, it burns with a flame of a changeable colour, between blue and yellow; and if in an open fire, the calx riſes in form of ſoft *white flowers* [*b*]; but if in a covered veſſel, with the addition of

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It melts at a lower heat than *copper* or *ſilver*; but at a higher degree than *lead* or *tin*, according to *Kirwan*, *pag.* 312. Bergman affirms its melting to be at the 699° of Fahrenheit's thermometer.

When broken it looks as if its whole texture was a compound of looſe cubical grains. *Gellert's* Metall. Chymiſt. chap. 7. p. 32.

It cannot be reduced into powder under the hammer like other ſemi-metals. When it is wanted very much divided, it muſt be granulated, by pouring it while fuſed into cold water: or filed, which is very tedious, as it ſtuffs and fills the teeth of the file. But if it be heated the moſt poſſible without fuſing it, Macquer aſſerts, that it becomes ſo brittle as to be pulveriſed in a mortar.

This property is very different from that of metals, which become more ductile by the action of fire.

The facets which the pigs of zinc preſent in their fracture, indicate that it is cryſtalliſable: and Mongez found that its cryſtallization conſiſts of bundles of ſmall quadrangular priſms, variouſly diſpoſed on all ſides, of a blue colour, which changes if expoſed to the air. *Fourcroy.*

[*b*] Theſe are called *Flowers of Zinc*, which are very fixed in the fire, and ſoluble in acids. *Kirwan.*

The calces of all metals and ſemi-metals may be reduced again into their metallic form, by the addition of proper phlogiſtic ſubſtances; but the white calx of zinc admits of no reduction. *Cramer.*

ſome

some inflammable substance, it is distilled in a metallic form; in which operation, however, part of it is sometimes found vitrified.

e. It unites with all the metals, except bismuth, and makes them volatile [c]. It is however not easy to unite it with iron without the addition of sulphur [d]. It has the

[c] Zinc also does not mix in fusion with Nickel, nor with Bismuth. How carefully soever it be stirred and mixed with either of these, the zinc, when grown cold, is found distinct upon the surface, so as to be readily separated by a blow.

It brightens the colour of iron almost into a silver hue; changes that of copper to a yellow, or gold colour, as mentioned pag. 676. and note [g] pag. 707. but greatly debases the colour of gold and destroys its malleability. One hundredth part of zinc renders this most ductile metal brittle and intractable. A mixture of equal parts of gold and zinc forms a very hard, white metal, which bears a fine polish, and was proposed by Hellot for making specula of reflecting telescopes, as it never rusts nor tarnishes when exposed to the air.

It improves the colour and lustre of lead and tin, rendering them firmer, and consequently fitter for sundry mechanic uses. Lead will bear an equal weight of zinc, without losing too much of its malleability.

Arsenic, however, which whitens all other metals, renders zinc black and friable; and when this mixture is made in close vessels, an agreeable aromatic odour is perceived on opening them. *Lewis.*

[d] Zinc, however, does not unite in the least with sulphur, or with crude antimony, which scorify all other metallic substances, except gold and platina; nor with compositions of sulphur and fixed alcaline salts, as *liver of sulphur*; which dissolve gold itself. Hence zinc may be purified from the lead, of which it commonly has some admixture, by injecting sulphur upon it in fusion; for the lead is absorbed by the sulphur, and forms with it a concrete, which floats unmelted on the surface, and may be easily scummed off. *Lewis.*

ſtrongeſt attraction to gold and copper, and this laſt metal acquires a yellow colour by it; which has occaſioned many experiments to be made to produce new metallic compoſitions [e].

f. It is diſſolved by all the acids: of theſe the vitriolic acid has the ſtrongeſt attraction to it; yet it does not diſſolve it, if it be not previouſly diluted with much water. The abundance of phlogiſton in this ſemi-metal is perhaps the reaſon of its ſtrong attraction to the vitriolic acid.

g. Quickſilver amalgamates more eaſily with zinc than with copper, by which means it is ſeparated from compoſitions made with copper.

h. It ſeems to become electrical by friction, and then its ſmaller particles are attracted by the loadſtone; which effects are not yet perfectly inveſtigated; but they may excite philoſophers to make farther experiments, in order to diſcover whether the electrical power ſhews itſelf in the metals, by being attracted by the loadſtone, or whether the magnetic power can be exerted on other metals than iron [*f*].

S E C T.

[*e*] The proceſs for giving the yellow colour to copper, by the mixture of zinc, and of its ore called *Calamine*, has been deſcribed in Sect. 332. pag. 707. See alſo N° 3. of the note to p. 672. *The Editor*.

[*f*] It has been ſaid, already, in the note to p. 756. that no other metal beſides iron, or in which ſome iron particles are contained, has any true attraction to the load-ſtone.

SECT. 357. (Additional.)

Native Zinc.

Zinc has been found native, though rarely, in the form of thin and flexible filaments, of a grey colour, which were easily inflamed, when applied to a fire.

Bomare asserts to have seen many small pieces of native zinc among the calamine-mines in the Duchy of Limbourg, and in the zinc-mines at Goslar, where this semi-metal was always surrounded by a kind of ferrugineous yellow earth, or ochraceous substances; and adds, that he did not know any author who had mentioned the existence of this native zinc at Goslar.

Various mineralogists have entertained, indeed, their doubts, about native zinc; but this being a simple negative argument, cannot invalidate the positive assertion of such an eye-witness as Bomare. Besides, our own Author speaks very positively in the following Sect. 361. of zinc in a *metallic form*, mineralised by sulphur; and there is not the least contradiction, in admitting that it may be equally found alone without any mineralizer.

The Editor.

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stone. Even pieces of brass and other metals, which shew not the least attraction to the magnet, if they are hammered, or pounded in an iron mortar, or with an iron-pestle, or hammer, are found often to have acquired a magnetical power, although there be not the least visible particles of the iron attached to them. *See however* Sect. 389. *and fol. The Editor.*

SECT. 358. (228.)

Zinc in a calciform state.

Zinc is found,

A. In form of calx, *Zincum calciforme naturale.*

1. Pure, *Minera zinci calciformis pura.*

a. Indurated, *Indurata.*

1. Solid.

2. Crystallised.

This is of a whitish grey colour, and its external appearance is like that of a lead spar; it cannot be described, but is easily known by an experienced eye. It looks very like an artificial glass of zinc, and is found among other calamines at Namur, and in England [a].

SECT.

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[a] The pure zinc-ore, according to Bergman, is mineralized by the *aerial acid*; and is generally distinguished by the name *vitreous*, on account of its similarity to the artificial glass of zinc; as the Author remarks in the text, it is sometimes hard enough to strike fire with hard steel, becomes yellow when roasted, effervesces, and dissolves almost intirely with acids, particularly the vitriolic and marine. Brunnich says, that this ore is sometimes found in the form of *stalactites.*

The English mines at Mendip hills contain a good deal of calamine; among several varieties, I got one in polyhedral crystals, as a very scarce one. The miners call it *Bony Calamine.* *J. R. Forster.*

The

SECT. 359. (Part of 228.)
Calamine.

2. Mixed, *Minera zinci calciformis impura.*

a. With a martial ochre, *Ochra five calx zinci martialis.*

1. Half indurated, *Ochra zinci indurata.* Calamine, *Lapis calaminaris* [a].

Whitish

The zinc spar is of a whitish, grey, bluish-grey, or yellowish colour, and of a hardness generally sufficient to strike fire with steel.

In its fracture it resembles *quartz*. It is amorphous, stalactitical, or crystallized in groups, and weighty.

By calcination it loses $\frac{1}{3}$ of its weight, without emiting any sulphureous or arsenical smell.

Is infusible in the strongest heat, either singly or with mineral alkali; but is fusible either with borax or microcosmic salt.

In the mineral acids it is soluble with effervescence: and, with the vitriolic, affords vitriol of zinc.

100 gr. of this ore contains about 65 of the calx of zinc, 28 of aerial acid, 6 of water, one of iron, and sometimes a little silex. *The Editor, from* Kirwan, p. 313.

[a] Calamine is of various colours, *viz.* white, grey, yellow, brown, or red. It is not so brittle as the tutenago-ore; but is of various degrees of hardness, though scarcely so hard as to strike fire with steel.

Its structure is either equable or cellular; and its form is either amorphous, or crystallized, or stalactitical.

When calcined it loses no part of its weight, except it be mixed with charcoal, and then flowers of zinc sublime.

It is soluble in acids; and, with the *vitriolic*, affords *vitriol of iron* as well as of zinc; which shews that the iron it contains is not much dephlogisticated.

a. Whitish yellow, from Tarnovitz in Silesia, England, and Aix-la-Chapelle.

b. Reddish brown, from Poland and Namur.

This seems to be a mouldered or weathered blende.

2. *b.* With a martial clay or bole, from Hollberget in Norberke, in Westmanland. Sect. 135. (86.) *d.*

c. With a lead ore and iron, England.

The specific gravity of the best sort, that is the grey, is =5,000. 100 parts of this afforded to Bergman 84 of *calx of zinc*, 3 of *iron*, 1 of *argill*, and 12 of *silex*. But in other specimens, these proportions are very different. A good ore should afford at least 30 *per cent*; and its specific gravity should be about 4,400, or 5,000.

Some of these ores are not so poor as not to contain above 4 *per cent*. of calx of zinc.

Calamines contain sometimes a mixture of calcareous earth and lead. Most of the English calamines contain lead. Kirwan, p. 315.

The *Tutenago-ore*, brought from China, and analysed by Engestrom, is an ore of zinc, in which a notable proportion of iron is contained. It was of a white colour, interspersed with red streaks of calx of iron, and so brittle as to be easily broken betwixt the fingers. It did not lose weight by being roasted; was soluble in the mineral acids, particularly with the assistance of heat; and, with the vitriolic, afforded vitriol both of zinc and of iron. The quantity of fixed air was so small as to be absorbed by the solution. It contained from 60 to 90 *per cent*. of zinc: the remainder was iron, and a small proportion of argill. Biddheim discovered also this variety of zinc-ore in Germany; which contained also a little *iron* and some *silex*. *The Editor from* Kirwan, p. 314.

SECT.

SECT. 360. (Additional.)

Zeolytiform Zinc-ore.

The real contents of this substance were first discovered by Pelletier, a most accurate Parisian chymist.

It was long taken for a zeolite, being of a pearl-colour, crystallised, and semi-transparent.

It consisted of laminæ, diverging from different centers:

And becoming gelatinous with acids.

It was commonly called *Zeolyte of Friburgh.*

And contains 48 to 52 *per cent.* of quartz, 36 of calx of zinc, and 8 or 12 of water. Ed. from Kirwan, p. 318.

SECT. 361. (229.)

Zincum Mineralisatum.

B. Mineralised zink,

1. With sulphurated iron, *Zincum ferro sulphurato mineralisatum.* Blende, Mock-lead, Black jack, Mock ore: the *Pseudo-galena* and *Blende* of the Germans [a].

Mineralised

[a] According to Mongez, the pseudo galena is sometimes semi-transparent, and crystallised; and almost always intermixed

a. Mineralised zinc in a metallic form, *Zincum formâ metallicâ sulphuratum*. Zink ore.

This is of a metallic blueish grey colour, neither perfectly clear as a potter's ore, nor so dark as the Swedish iron ores [*b*].

1. Of a fine cubical or scaly texture, from China, Kongsberg, and Jarlsberg in Norway.
2. Steel-grained, from Bowallen and Skienshyttan, in the parish of Tuna, in Dalarne.

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intermixed with *silver*, *lead*, *copper*, *arsenic*, and other metals, as well as with argillaceous and calcareous earth. But, as Bergman observes, the *zinc*, *iron*, and *sulphur*, are the only necessary ingredients for the formation of this ore.

[*b*] The principal varieties of *blende*, or *pseudo-galena*, are, 1. The Scaly form, and that composed of small cubes, similar to the *galena*. It is of a dark grey colour, and sometimes strikes fire with hard steel.

2. The scaly greenish-black coloured ore, resembling pitch, called *Pechblende* by the Germans. See the following Section.

3. The *red* coloured; which produces a reddish powder when scraped with a knife, and turns yellowish by calcination.

4. The phosphoric, or sparkling blend, to be mentioned in Note to Sect. 362. which is of a yellowish colour, or opake, or semi-transparent; and, on being rubbed with a pen, in a dark place, it produces luminous sparks of a yellowish light. From Mongez.

5. And the *red*, phosphorescent when rubbed, which is found at Scharfenberg in Misnia, as Brunnich asserts. *The Editor.*

In all probability this ore is the *glanz blende* of Sect. 363. where its full description may be seen. *The Editor.*

SECT. 362. (230.)

Zinc Pseudo-galena.

b. In form of calx, *Zincum calciforme cum ferro sulphuratum.* Blende. Mocklead, *Sterile nigrum. Pseudogalena.* This is found, [a]
1. With coarse scales,
a. Yellow, semi-transparent, from Scharffenberg in Misnia, Schemnitz and Kongsberg [b].
b. Greenish, from Kongsberg.

Black,

[a] There are several varieties of *Pseudo-galena*, or *Black Jack.* They are in general of a lamellar, or scaly texture, and frequently of a quadrangular form, resembling *galena.* They all lose much of their weight when heated, and burn with a blue flame; but their specific gravity is considerably inferior to that of true *galena.* Almost all contain a mixture of lead-ore. Most of them exhale a sulphureous smell, when scraped; or at least when vitriolic or marine acid is dropped on them. *The Editor from* Kirwan, p. 319.

[b] This ore is as yellow as wax; is semi-transparent, and contains much sulphur.

In the dry way zinc is reduced from this ore, by distilling it, after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, in a strong heat: but, by this method, scarce half of the zinc it contains is obtained. Kirwan, p. 323.

Another greyish yellow blende is found also, that consists of a mixture of blende, galena, and petrol.

It contains about 24 *per cent.* of zinc, and is probably the same as the grey blende mentioned by Monnet. Kirwan, p. 323.

This

c. Black, *Pechblende* or *Pitch Blende* of the Germans, from Salberg and Falun in Sweden, and from Saxony.

d. Blackish brown, from Storfallsberget in Tuna in Dalarne [c].

2. With fine scales [d],

a. White, from Silfberget in the parish of Rettwik in Dalarne.

b. Whitish yellow, from Rettwik.

Reddish

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[c] This ore is of a black colour, and of a moderate hardness.

It does not give fire with steel.

Is frequently cryſtallized; and

Is then ſometimes tranſparent, or ſemi-pellucid:

When pulverized it affords a reddiſh powder.

If heated it decrepitates: emits a ſulphureous ſmell, if laid on burning coals: and depoſits white and yellow flowers.

It is not magnetic, even after torrefaction, but loſes 25 per cent of its weight.

It is frequently mixed with ſilver, arſenic, and other metals.

100 parts of this ore, from Danemora, being examined by Bergman, exhibited 45 of zinc; 1 of regulus of arſenic; 9 of iron; 6 of lead, all ſlightly dephlogiſticated; 29 of ſulphur; 6 of water; and 4 of ſilver. *Kirwan*, p. 321.

[d] The cryſtallized blendes deſerve to be mentioned in this place:

a. Dark red, very ſcarce; found in a mine near Freyberg. Something like it is found at the Morgenſtern and Himmelsfürſte.

b. Brown. In Hungary and Tranſilvania.

c. Black. Hungary.

Theſe laſt varieties may eaſily be miſtaken for tin-cryſtals; but, by experience, they may be diſtinguiſhed on account of their lamellated texture and greater ſoftneſs.

Their tranſparency ariſes from a very ſmall portion of iron in them. *Brünnich.*

The

2

c. Reddish brown, from Salberg, Silfverberget, and Hellefors in Westmanland [e].

3. Fine and sparkling; at Goslar called *Braun Bleyertz* [f].

Dark

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[e] The texture of this ore is generally scaly: sometimes crystallized and semi-transparent.

It gives fire with steel; but

Does not decrepitate, nor smoke when heated:

Yet it loses about 13 *per cent.* of its weight by torrefaction.

One *hundred* parts of this ore, from Sahlberg, contained (by Bergman's analysis) 44 of zinc, 5 of iron, 17 of sulphur, 5 of water, 5 or argill, and 24 of quartz. *See the process for analysing this ore, in* Kirwan, p. 322.

[f] There is a red blende, which becomes phosphorescent when rubbed. This is found at Scharfenberg in Misnia: *Brunnich.*

Another *Phosphorescent Blende* is generally greenish, yellowish-green, or red; and has different degrees of transparency; and is sometimes quite opaque.

When scraped with a knife in the dark, it emits light, even in water; and after undergoing a white heat, if it is distilled *per se*, a siliceous sublimate rises, which shows it contains the *sparry acid*, probably united to the metal, since it sublimes.

This ore is almost wholly soluble in the marine acid with a boiling heat.

Bergman found 100 *gr.* of this ore from Scharfenberg, to contain 64 of zinc; 5 of iron; 20 of sulphur: 4 of *fluor acid*; 6 of water; and 1 of silex. *Editor from* Kirwan, *p.* 323.

The zinc, in the last kind of blendes mentioned in this Section, is, as it were, in the form of a calx or glass, so that they are often transparent. On the contrary, in the zinc ore of Sect. 361. [a], it seems to be in a metallic form, or, like most other metals, mineralised with sulphur.

The sulphur, nevertheless, exists in the different kinds of blende; equally as in the zinc-ore: and this remarkable difference in their appearance must be accounted for from another principle than the quantity of zinc which they contain;

a. Dark Brown, from Rammelsberg in the Hartz, and Salberg in Westmanland.

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tain; because the yellow and the white blendes are often found to be richer than the zinc-ores; but these last are, however, more profitably worked for the metal. Perhaps it is because the blend does not contain a sufficient quantity of the phlogiston of the sulphur, to prevent the calcination of the zinc.

It is no matter whether a calcined blende is called *calamine* or not, provided it has such properties, that it may be employed to the same purposes, and with the same effect as that calamine, which nature has freed from its sulphur, by its withering or decaying. This may be done with some kinds of blende; and Mr. Von Swab has given evident and excellent proofs of it in Sweden; in so much that it would demonstrate a want of experience to insist that sulphur cannot be expelled by calcination, without destroying the zinc itself; and that flowers of zinc may be produced from zinc ores in a calcining heat, without addition of any phlogiston.

Mr. Justi, however avers, that he has found an ore of this quality, which in his Mineralogy he calls *Zinc-spat*; but there is great reason to doubt whether it really contains any zinc, until it is shewn whether the author added any phlogiston during the calcination, or reduced the zinc out of it; because, although the flowers of zinc may not always be perfectly well calcined, yet there is no instance of a natural zinc-ore being discovered, which by itself yields those flowers during calcination. And it requires, besides, a strong heat to produce these flowers from a perfect calx or glass of this semi-metal, either natural or artificial, though mixed with a phlogiston: for it could not have been a native zinc, since it resembled a spar, and such a one very likely is not to be found in nature. *The Author.*

SECT.

SECT. 363. (Additional.)

Glanz blende [a].

This ore has a metallic appearance.

Is of a bluish grey.

Its form is generally cubical or rhomboidal.

Is of a scaly or steel-grained texture.

It loses nearly one sixth of its weight by calcination; and after calcination it is more soluble in the mineral acids.

One hundred parts of this ore afforded to Bergman about 52 of *zinc*; 8 of iron; 4 of copper; 26 of sulphur; 6 of silex; and 4 of water. *Kirwan.*

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[a] To analyse this ore in the *moist way*; Bergman first expelled the water and part of the sulphur by distillation. The residuum he treated with 3 times its weight of oil of vitriol, carrying the evaporation to dryness; this he lixiviated with warm water, and found only 6 parts undissolved. In this solution a polished plate of iron was boiled, which precipitated the copper. He then, by means of the phlogisticated alkali, precipitated the *zinc* and *iron*. The precipitate being calcined in an open fire, was several times treated with nitrous acid, and evaporated to dryness, until the iron was perfectly dephlogisticated; fresh nitrous acid being then added, dissolved the zinc only, which being precipitated by the Prussian alkali, the proportion of zinc was found in its metallic state.

Neither metal contained in this ore is much dephlogisticated. *See the process properly described by Kirwan, at p.* 317 *and following.* The Editor.

SECT.

SECT. 364. (122-3)

Zinc mineralised by the vitriolic acid.

This ore has been already described in Sect. 210. and in the notes p. 411.

SECT. 365. (231.)

Observations on Zinc [*a*].

It appears from old coins, and other antiquities, that the making of brass was known in

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[*a*] 1. Zinc is also called by Neumann and various other authors by the names of *Tutenago*, *Spiauter*, *Contrefait*, and *Spelter*. The Dutch bring to Europe, in the *East India* ships, a great quantity of *tutenago*, which is a little *bluer* than the German zinc, and also more tenacious. But we know nothing certain (says Cramer), either of the country where the ore that contains this zinc is found, and much less of the manner in which this semi-metal is obtained from it: for it is afferted that no European is granted the liberty of entering into the Chinese manufactories.

2. We have obtained, however, since the time of Cramer, some knowledge respecting the contents in the Chinese *tutenago* ore, as appears by the last note to Sect. 359. pag. 776.

3. As to the German zinc, it is well known, that it is not extracted from any ore by eliquation, as other metals and semi-metals are melted out from theirs; and in fact all the zinc that is there prepared is obtained by sublimation, not from

in the most antient times; and that it was their *Æs Corinthiacum*, which contained copper and zinc. But it is not long since this semi-metal was discovered to lie concealed in calamine, and that calamine was its peculiar ore, and also a body of distinct qualities, prepared by nature, equal to that which is got tolerably pure at the furnaces of Goslar, or that is imported from China, under the name of *tutenago*.

Mr.

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from any singular ore, but out of an intricate and confused mixture of different ores, some of which contain zinc; at the same time that several other metals, and semi-metals, are separated from the same, such as *iron*, *lead*, and *copper*, which are almost all combined with *sulphur*, and *arsenic*.

3. And moreover no peculiar sublimation is there employed for the extraction of that zinc, it being only by a secondary operation, that the volatile fumes of zinc are collected at the same time, during the eliquation of the other metals, especially of lead. It may be easily conceived by the description given by Cramer of the smelting furnaces of Goslar, that it must have been merely chance without design that the upper channel was applied within them, by which a very small part of the volatilized zinc, is preserved and reduced into its reguline form; so that out of the vast quantity of ores smelted there which, within the space of 18 hours, is more than 60,000 weight, hardly 3, or at most 5, pounds of zinc are obtained.

4. Pott, on his *Essay on Zinc*, says, that our countryman, Dr. Isaac Lawson, of whose great knowledge in mineral chemistry he speaks very respectfully, really obtained some small quantity of regulus of zinc from *calamine*; and makes several quotations from a Dissertation published by the same Dr. Lawson, upon the *nihil*, or *flowers of zinc*. Dr. Campbell likewise asserts positively, in his *Survey of Great Britain*, that Dr. Lawson discovered *calamine* to be the true mine of this semi-metal. In all probability this was the same learned gentleman, by whom Cramer had been employed in Eng-

Eee land,

Mr. Brandt removed a great many doubts about the origin of zinc, and the metallic earth of the calamine, by having in the year 1734, a favourable opportunity of examining the calamines, and different kinds of blends, from Rettwik in Dalarne. He then proved, in his *History of the Semi-metals*, that blends and calamines are ores of zinc; and that the *Galitzenstein* (Sect. 210 of this Edit.) of the Germans was its vitriol.

Soon

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land, as his Operator in chemistry. He resided a long time afterwards at Leyden, living in great intimacy with *Boerhaave*, *Vanswieten*, *Gaubius*, *Grenovius*, and with several other men of great learning in that flourishing university, and went at last to Flanders, where he died in the year 1745. It is to his care and trouble of reducing into order, and writing for the press, the *course of lectures* and *experiments*, given at Leyden in 1735, to a society of gentlemen, most distinguished for their skill in all branches of natural philosophy, that the world is indebted for that excellent work, intitled *Elements of Essaying Minerals*, by *J. A. Cramer*. This last gentleman did collect, indeed, the chief part of the materials; but they would probably have remained buried in oblivion, without the assiduous labour and industrious care and intelligence of Dr. Lawson, as may be seen by the advertisement prefixed by Dr. C. Mortimer to the second edition of that work.

5. It deserves notice, however, that, although Dr. Lawson was acquainted with the method of smelting zinc from calamine, he never gave the least hint of the process in the said work of Cramer. Perhaps he was in hopes of publishing it afterwards at large, in a compleat work on the subject, from which performance he was unhappily prevented by his untimely death. It is proved, beyond all controversy, by the arguments and authorities adduced by Dr. Watson, in the second Essay of his fourth volume, that the ancients, and particularly the Romans, formed their *orichalcum*, as we do our *brass*, by melting copper with calamine, &c. This

4 operation

Soon after, the bluish-grey zinc-ore was discovered by Mr. Von Swab at Bowallen, who, in the year 1738, prepared calamine from it, and erected a work for distilling zinc at large from it, at Westerwiken in Dalarne; which manufacture, however, afterwards was laid aside for other intervening business.

Thus these first discoverers might perhaps have given to Messieurs Pot and Margraff, the opportunity

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operation has been fully described in the note [*g*] to Sect. 332. p. 707. But it was reserved for modern metallurgists to discover, that this phenomenon is produced by a volatile substance, which can assume a solid state or form, like any other semi-metal.

6. The two principal ores of zinc are now very well known to be *calamine* and *blende*. The name of the first is taken from the Arabic *climia* or *calamia*, which denotes, as Watson asserts, the very same semi-metal; but, by the word *blende*, the Germans mean a *misleading* or *blinding* mineral; because, notwithstanding the great resemblance of *blende* to the *lead-ore*, on account of its shining particles, nevertheless it does not yield any lead at all. From thence blende is also called the *Pseudogalena*, and *Mock-lead*; and in fact many unexperienced smelters have been deceived by this great similarity, buying *blende* for the true *galena*, which is called *Potter's lead ore* of Derbyshire. But in general *blende* is better known among our English miners by the nick name of *black-jack*; by whom it is disposed of to the makers of brass.

7. Calamine is found in many parts of Europe: and we have great plenty of it in *Somersetshire*, *Flintshire*, *Derbyshire*, and in many other parts of England. It is scarcely to be distinguished by its appearance from some sorts of *lime-stone*; for it has none of the metallic lustre usually appertaining to ores, and only differs by its specific gravity, it being near twice as heavy as *flint* or *lime-stone*.

8. The first dressing of the calamine consists in picking out all the pieces of *lead-ore*, *lime*, and *iron-stone*, *cauk*, and

 other

opportunity to make the history of zinc more known to the world: the former in his *Treatise de Pseudogalena* in the year 1741; and the latter, in the *Memoirs* of the Academy of Berlin: though this notice is by no means intended to deprive these ingenious gentlemen of the honour they merit, for having had of themselves the same opinion, and proposing the same experiments.

The

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other heterogeneous substances, which are found mixed with it in the mine: it is then calcined in proper furnaces, where it loses about a fourth or third part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more discernible, by the action of the fire; it is then ground to a fine powder, and washed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; so that, by these processes, a *ton* weight of the crude calamine of Derbyshire is reduced to *twelve hundred* only.

9. As to the *blendes* or *black-jack*, they vary very much in their external appearances and internal constitutions, as was described in the preceding sections. In general, the blendes contain *zinc* and *sulphur* united together by the intervention of *iron*, or of *calcareous earth*; and must be previously freed of the *sulphur* by means of calcination, to produce zinc.

Bergman asserts that a certain Englishman made, several years ago, a voyage to China, for the purpose of learning the art of smelting zinc, or tutenago; but though he became instructed in the secret, and returned safely home, he carefully concealed it.

10. The manufactory of zinc was, however, established in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the first work of the kind near Bristol. It consists, as Watson relates, of a circular kind of oven, like a glass-house furnace, in which were placed 6 pots, of about 4 feet each in height, much resembling large oil-jars in shape, into the bottom of

each

The zinc from Ramelsberg in the Hartz, is like most of the lead and copper ores from the same mines of a very fine grained texture, which we call *Steel-compact*; and is likewise so often equally mixed with the said copper and lead ores, as not to be so easily perceived, if one is not previously acquainted with them. It seems, nevertheless, reasonable that a true mineralist ought rather to suspect the ore called *Brown*

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each pot is inserted an iron tube, which passes through the floor of the furnace, into a vessel of water. A mixture of the prepared ore, as mentioned above Nº 8 and 9, is made with charcoal, and the pots are filled with it to the mouth, which are then close stopped with strong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine issues downwards, or *per descensum*, through the iron tubes, there being no other place through which it can escape; and the air being excluded, it does not take fire, but is condensed in the water into granulated particles; which being remelted, are cast into ingots, and sent to Birmingham under the name of *zinc* or *spelter*; although by this last name of *spelter*, only a granulated kind of soft brass is understood among the brasiers, and others who work in London, used to solder pieces of brass together.

11. Great part of the zinc volatilized, by the force of fire in large furnaces, as those at Goslar, adheres to their sides in the form of a whitish calx; this is scraped off, when the furnace is cold, and is called by the name of *Ofenbruch*, or *Cadmia fornacum*, which is employed, as well as zinc, to make brass.

12. Another substance, common in the shops, is called *Tutia*, or *Tuthia*, according to Lemery. This seems to be some preparation of the calx of zinc with other matters, and varies very much in its contents, as well as external appearances: it changes, or ought to change, copper also into brass; and is employed in the composition of some unguents by the apothecaries, although the effects must vary, according to the integrant parts of this compound.

Brown Bleyertz (Sect 362-3) to be a zinc-ore, than to suppose this semi-metal to be a product of *lead*, *copper*, and *iron*.

SECT. 366. (232.)

4. Antimony. *Antimonium. Stibium.*

Its general properties [a].

This semi-metal is,

a. Of a white colour almost like silver.

Brittle:

13. The *Pompholix*, *Diphryges*, *Nihil*, *Nihil album*, *Spodium Græcorum*, *Cadmia botrites*, *Zonites*, *Onychites*, *Ostracites*, *Placites*, *Capnites*, &c. mentioned by medicinal and metallurgical writers, are productions of zinc, with various external appearances of colour, and consistence or form, which differ very little, or perhaps nothing at all, from themselves in their properties; but are cherished by whimsical authors on account of the singularity of their names. *The Editor* from *Neumann*, *Watson*, &c.

[a] The colour of antimony, in its reguline form, is of a silver white; its texture appears micaceous; and is remarkably brittle.

Its specific gravity, when perfectly freed from iron, is = 6,860.

The *nitrous acid* dephlogisticates antimony; but holds only a very minute portion of it in solution.

The *vitriolic acid*, if boiling, dissolves antimony; but the *muriatic* and *acetous* acids act hardly at all upon it, unless previously calcined.

Aqua regia formed of 7 parts of *marine* and one of *nitrous* acid, dissolves this semi-metal in a considerable degree.

It is also soluble in a mixture of the *vitriolic* and *marine* acids, or even of the *vitriolic* and *nitrous* acids.

The

b. Brittle; and in its texture, it consists of shining planes, of greater length than breadth.

c. In the fire it is volatile, and volatilises part of the other metals along with it, except gold and platina. It may, however, in a moderate fire, be calcined into a light grey calx, which is pretty refractory in the fire, but melts at last to a glass of a reddish brown colour.

d. It dissolves in spirit of sea-salt and *aqua regia*, but is only corroded by the spirit of nitre into a white calx; it is precipitated out of the *aqua regia* by water.

It

The phlogiston it loses by solution, is expressed by 120; and in respect to the force wherewith it retains this, it stands in the *sixth* place.

It melts in the fire long after it becomes *red hot*; *viz.* at the 809 *degree*; provided it be in its pure reguline form; otherwise it melts at the flame of a candle. When melted, it emits a white smoke, and evaporates, forming itself into white and refractory flowers, as the author remarks. *See the* Nº 10 *of the note to Sect.* 372.

In close vessels it sublimes without decomposition. *Bergman, Kirwan,* &c.

Crude antimony soils the fingers, when handled.

It is found in different parts of Europe, as Bohemia, Saxony, Transylvania, Hungary, Sweden, Spain and France, &c. it commonly lies alone in mines, intermixed with earthy or stony matters.

Sometimes it is blended with the richer ores of silver, and renders the extraction of that metal very difficult; for the antimony volatilises a part of the silver; or *robs the ore*, as the miners express themselves.

It is separated from its natural impurities by fusion, in an earthen pot, whose bottom is perforated with a number of

e. It has an emetic quality when its calx, glass, or metal, is dissolved in an acid, except when in the spirit of nitre, which deprives it of this effect.

f. It amalgamates with quicksilver, if the regulus when fused, be added to it; but the quicksilver ought for this purpose to be covered with warm water: it amalgamates with it likewise, if the regulus of antimony be previously melted with an addition of lime.

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holes; it is then surrounded by burning coals: the fluid antimony passes through the holes, whilst the unfusible matters remain behind. This melting vessel must have been let into the mouth of another pot, sunk in the ground, which serves as a receiver, in this kind of melting *per descensum*. The juncture of the two vessels must be closely luted; and several sets of this apparatus are generally worked at once. *See the last* Nº *of the note to Sect.* 369.

In the purification of gold, when it contains other metals, antimony is employed. *See* the Nº 8 of the note to Sect. 372.

The *flowers of antimony*, already mentioned, are nothing else but its pure calx; and, if put in a proper degree of fire, in a close crucible, produce a brownish red glass of a deep hyacinthine colour. See Nº 12 of the Note to Sect. 372.

If antimony is melted in a close crucible, and is cooled gradually, it assumes the form of insulated pyramids, and sometimes of a regular form of stars.

This semi-metal combines very well with sulphur.

Crude antimony being projected in a crucible, in which an equal quantity of nitre is fused, detonates; is calcined, and forms a compound, called by the French, *Fondant de Rotrou*, or *Antimoine Diaphoretique non lavé*. This being dissolved in hot water, falls to the bottom after it is cold; and after decantation, is known, when dry, by the name of *Diaphoretic Antimony*. *Mongez*. See the note to Sect. 372, Nº 20.

SECT.

SECT. 367. (233.)

Native Antimony.

Antimony is found in the earth.

A. Native, *Antimonium nativum, ſive, Regulus Antimonii nativus.*

This is of a ſilver colour, and its texture is compoſed of pretty large ſhining planes.

This kind was found in Carls Ort, in the mine of Salberg, about the end of the laſt century [*b*], and ſpecimens thereof have been preſerved

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[*b*] Since native antimony, or, as it is commonly called, *regulus of antimony*, was never before known, the poſſibility of its exiſtence has been denied; and when the ſpecimen here mentioned, was diſcovered, a certain perſon publiſhed his doubts of the truth of the whole affair, upon no better foundation than that the ſpecimens were very ſmall for making experiments, and that it was uncertain if ever mineraliſed antimony had been found in the mine of Salberg.

But thoſe reaſons are not ſufficient to refute experiments, becauſe men of experience are always able to make true experiments on ſmall pieces of native metal; nor is there any neceſſity that mineraliſed metals ſhould always be found along with the native ores of the ſame ſpecies; though this really happens with this antimony in the mine at Salberg.

We ought to be contented with concluſions drawn from experiments, until the fallacioufneſs of ſuch experiments is demonſtrated. And it were to be wiſhed, that all pretended diſcoveries were ſupported by experiments, and an enumeration of the phenomena which happen in them; we ſhould then not contradict things, which perhaps may be true, though, for want of this precaution, they ſeem ſcarce credible; as, for inſtance, the *native tin*, *lead*, and *iron*, the preserved in collections under the name of an arsenical pyrites, till the mine-master Mr. Von Swab discovered its real nature, in a treatise he communicated to the Royal Academy of Sciences at Stockholm, in the year 1748. Among other remarkable observations in this treatise, it is said, *first*, That this native antimony easily amalgamated with quicksilver; doubtless, because it was imbeded in a limestone; since, according to Mr. Pott's experiments, an artificial regulus of antimony may, by means of lime, be disposed to an amalgamation.

Secondly, that it yielded cristals *in forma calcis*, during the cooling.

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the *zink spar*, and an unknown semi-metal in the mica. *The Author.*

Counsellor Muller, in a letter of the 21st September 1782, inserted in *Journ. de Physique*, for July 1787, and directed to Baron de Born, pretends that the above ore of *native antimony*, acknowledged as such by Mr. Von Swab, was nothing but a true native bismuth. Mr. de Reprecht, however, wrote, on the 20th of October following, a full refutation of C. Muller's arguments, to the same Mr. de Born. This last letter was also inserted in the next article of the same *Journal de Physique*; and shews the power of old prejudices, in spite even of ocular demonstrations.

But Mr. de Reprecht, it seems, has recanted, *honourably*, if influenced only by the love of truth! *See pag.* 231. *of the same* Journal *for September following*.

It appears by the same letters, that *native antimony* is found also in different other ores, as those from *Fazebay* and Transylvania; and that the *blackgold-ores* from *Nagyag*, contain not only *gold*, but also *silver*, *iron*, *lead*, *antimony*, *arsenic*, and *sulphur*, whose respective proportions, Mr. de Ruprecht, had undertaken to ascertain.

And lastly, Mr. Mongez above quoted, has given a full account of the *native antimony* found in the mines of Allemond in Dauphiny by Mr. Schreiber, some samples of which he examined by the *dry* and *humid way*, which he found to be alloyed with about 3 *per cent.* of arsenic. See the Journal de Physique *for July* 1783, *p.* 66. The Editor.

SECT.

SECT. 368. (Additional.)

Antimony Mineralized by the Aerial Acid.

This ore was lately discovered by Mongez, among those of *native antimony*, from the mine of *Chalanges* in *Dauphiny*.

It consists of a group of white crystalized filaments of a needle-form appearance, diverging from a common center, like zeolyte.

They are insoluble in nitrous acid; and,

On being urged by the flame of a blow-pipe, upon a piece of charcoal, they are dissipated into white fumes, or antimonial flowers, without any smell of arsenic; from whence it follows, that these needle-formed crystals are a pure *calx of Antimony*, formed by its combination with, or mineralized by, the aerial acid. *See* Kirwan, *p.* 325, *and* Journal de Physique *for July* 1787, *p.* 67.

SECT. 369. (243.)

B. *Mineralized Antimony.*

1. With sulphur, *Antimonium sulphure mineralisatum. Antimonium proprie sic dictum* [c].

This is commonly of a radiated texture, composed of long wedge-like flakes or plates; it

[c] The mountains in Upper Hungary are all rich in these kinds of ore, especially in the county of *Liptaw*, whence it is exported to Poland. *Brunnich.*

The

it is nearly of a lead colour, and rough to the touch.

a. Of coarse fibres.

b. Of small fibres.

c. Steel-grained, from Saxony and Hungary.

d. Cristallised, from Hungary.

1. Of a prismical, or of a pointed pyramidal figure, in which last circumstance the poinss run to one center.

I have seen a specimen of this, in which the crystals were covered with very minute crystals of quartz, except at the extremities, where there was always a little hole. This specimen was given for a *flos ferri* spar.

The sulphureous ores of antimony are the most common, and the most productive of this semi metal.

The common *black-grey*, or *blueish antimony*, is most usually of a striated texture; yet there is some found without any determinate form, and in this case it may be easily mistaken for the *small-grained lead-ore*, or *white silver-ore*, or *iron-glimmer*; but the way to distinguish it immediately from these, is to hold only a piece of this ore in the burning flame of a candle; because the antimony will melt in that low heat, which none of the other ores does; an experienced eye may readily discover it by the colour.

Crude antimony is not only that which is separated and picked out in compact pieces from the stony or other heterogeneous matters of the ore; but also what is melted at first out of its mineral stones and earths, by fire. This ore has indeed its own regular veins like other minerals; and yet some other kinds of ores are sometimes found along with it. *Gellert's Metallurgy, p.* 59.

The texture of these ores is not only *fibrous*, and often *inclined* to a common centre, but also *cuneiform*, *striated*, *solid*, and lamellated: these last are sometimes called *Antimo-*

nial

nial Galenas. They are alſo found ſometimes in a *plumoſe form*, conſiſting of extremely delicate fibres, like feathers.

As to colour, they are not only *dark* or blueiſh-grey, but ſometimes they ſhow, in their needle-form maſſes, the fineſt *purple*, variegated with ſhades of *red*, *blue*, *green*, *yellow*, and *whitiſh-grey*, like the pigeon's neck.

Wallerius and Bomare deſcribe other varieties of theſe antimonial ores, which differ by colour or ſhape; but it will be ſufficient to indicate only their deſcriptive Latin epithets, *viz*.

Striatum colore griſeo.
Fibroſum plumbo-ſimile.
Fibris parallelis.
Striis inordinatis.
Striis decuſſantibus.
Striis intercuſſantibus.
Striis ex centro divergentibus.
Striis concentricis.
Striis ſtellatis.
Striis in plana nitida concretis.
Striato-ſquamoſum.
Lanæ inſtar, fibris capillaribus ſeparatis.
Plumoſum, { *album.* / *rubrum.* / *flaveſcens.* / *viride.* / *cæruleſcens.* }
Textura Chalybea.
Criſtalliſatum. { *figura incerta* / *fig. turrita ceu pyramidalis.* / *tuberoſa.* / *nodoſa.* / *druſica.* }
Griſeum ſpeculare, cinereum, &c.

The ſpecific gravity of antimony is for the moſt part from 4 to 4200; and, when melted, from 4700 to 500. But if the regulus be well depurated from ſulphur and iron, its ſpecific gravity is much greater, as was mentioned in the note [*a*] to Sect. 366.

This ore of antimony ſoils the fingers when handled, and is very brittle.

When

SECT. 370. (235.)

Red-Antimony Ore.

2. With sulphur and arsenic, *Antimonium auripigmento mineralisatum.* Red antimony ore, *Antimonium solare.*

This is of a red colour, and has the same texture with the preceding, though its fibres are not so coarse.

a. With small fibres.

b. With abrupt broken fibres, from Braunsdorff in Saxony, and from Hungary [*d*].

All

When gradually heated in a crucible, it loses about 22 *per cent.* of its weight; and becomes a grey calx.

It is perfectly soluble in the *marine acid*, with the assistance of heat.

The *nitrous* only calcines the reguline part.

100 parts of this ore contain 74 of the *antimonial regulus*, slightly dephlogisticated, and 26 of *sulphur*.

It is analysed by solution in *aqua regia*, consisting of 1 part of *nitrous*, and 4 parts of *marine acid*. The sulphur is found in the filter; for this solvent only acts on the semi-metal, and the sulphur being disengaged, floats over the solution.

In the *dry way* antimony is separated from the stony parts of its ore by distillation *per descensum.* It is afterwards reduced to a regulus by gently roasting it, until it loses 22,5 *per. cent.* of its weight; and then mixing the grey calx thus formed, with twice its weight of *black flux*, and briskly fusing it in a covered crucible, the regulus is obtained. *The Editor from* Kirwan p. 326, and Mongez, *&c.*

[*a*] In Hungary nobody knows this kind of ore. I only found it at Braunsdorff: therefore some, who have not seen it, deny its existence. *Brunnich.*

The

All antimonial ores are somewhat arsenical, but this is more so than the preceding kinds.

SECT. 371. (236.)

Mineralized with other metals.

C. With sulphurated silver. The *plumose silver ore* of Sect. 274 [e].

With

The red-colour of this ore proceeds from the mixture of arsenic. Wallerius speaks of 3 varieties of this ore, that are found in Hungary and Saxony, *viz.* 1. of a *red* colour; 2. of *purplish* or *violet*; and 3 of a *pale red* colour. *See the Spec.* 306 *of* Wallerius's System. Mineral.

Bomare describes also the following arsenical ores of antimony, which, in all probability, are the same mentioned by Wallerius after himself, *viz.*

1. The *red* with parallel fibres, *striis fere parallelis*, found at *Braunsdorff* in Saxony.

2. The *pale-red*, or of a *violaceous colour*, found at Presbourg in Hungary, and another of a *blue* colour found also at Braunsdorff.

4. The *red* with the striæ dispofed in a starry form, found in Hungary and Saxony.

4. The *purple red*, which is plumose, or of very thin silky fibres, like *hair*, or wool: and sometimes in a *dendritical* form, upon the white quartz of the grey ore of antimony, in the mine called the Old-Hope of God in Freyberg.

5. And the plumose ore of an *ash colour*, which is also found of a purple-red colour, at Braunsdorff in Saxony.

Finally, the same author speaks of a horn-antimony, *minera antimonii cornea*, which is said to have been found at Stolberg.

[e] Besides the colours of this ore mentioned in Sect. 274, there are also ores of the kind, which are *red* or *green*: and then they contain but a small proportion of silver. Their texture is filamentous, very brittle and fusible.

These

D. With sulphurated silver, copper, and arsenic. *See* Sect. 276 [*f*].

E. With sulphurated lead. *See* Sect. 314.

These ores may be analysed by solution in *aqua regia:* both the regulus of antimony and the arsenic remain in the solution, and the sulphur is separated by filtration. If the solution be then boiled with twice its weight of strong *nitrous acid*, the regulus of antimony will be precipitated on account of its dephlogistication; and, the arsenic which is then converted into an acid, will remain in the liquor, and may be procured by evaporation into dryness.

[*f*] If *silver* or *copper* be suspected in the scoriæ, they may be analysed by boiling in about 6 times their weight of of *dilute nitrous acid*, which will take up the silver and copper, and leave the regulus of antimony and the arsenic.

These last may be boiled in *strong nitrous acid*, which dephlogisticates the antimony, and the arsenic becomes soluble in water: so that the calx of antimony remains undissolved. The sulphur may be found in a second experiment, using *aqua regia* instead of the concentrated *nitrous acid*, and the silver may be precipitated with a clean plate of copper, previously weighed; for in this case, the silver precipitates upon it in its metallic form, which may be weighed, and its contents known. As to the copper, it may be precipitated by aerated mineral alkali; and 194 *gr.* of this precipitate well dried are equivalent to 100 *gr.* of copper in in its metallic form. But from this last, the weight lost by the copper plate, during the operation, must be substracted.

N. B. If in this solution by *aqua regia*, the precipitation of the silver should be attempted by the *marine acid*, it would unite to the copper, and form a triple salt, which would also be precipitated together.

If the residuum should casually contain *sulphur*, *arsenic*, and *iron*; by boiling it in the spirit of salt, the arsenic and iron will be taken up: the first (the arsenic), may then be precipitated by the addition of water, and the iron by the Prussian alkali, &c. *The Editor from* Kirwan, *p.* 327, 248 *and* 250.

SECT.

SECT. 372. (237.)

OBSERVATIONS on ANTIMONY [a].

By the name of Antimony is commonly understood the crude antimony, (which is compounded

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[a] 1. Though the regulus of antimony is a metallic substance, of a considerably *bright white colour*, and has the *splendor*, *opacity*, and *gravity* of a metal; yet it is quite *unmalleable*, and falls into powder, instead of yielding or expanding under the hammer; on which account it is classed among the *semi-metals*.

2. Dr. Lewis mentions an easy process to give a most brilliant metallic appearance to the regulus of this semi-metal. It consists in throwing a lump of *cauk* (or *terra ponderosa*) into the crucible, in which the antimony is melted in the fire; about one or two ounces of the *cauk* red hot will suffice for about 16 ounces of the melted semi-metal: and the fusion being continued about two minutes more, on pouring it off, there will be found about 15 ounces of the regulus, as brilliant as *polished steel*, or *pure quicksilver*.

3. Regulus of antimony is used in various metallic mixtures, as for *printing types*, *metallic speculums*, &c. It enters into the best sort of *pewter ware*.

4. It mixes with, and dissolves various metals; in particular it affects iron the most powerfully; and, what is very remarkable, when mixed together, the iron is prevented from being attracted by the *load-stone*, as was mentioned in the note, Nº 38, to p. 756.

5. It affects *copper* next, then *tin*, *lead*, and *silver*; promoting their fusion, and rendering them all brittle and unmalleable; but will neither unite with *gold*, nor *mercury*; though it may be made to combine with this last by the interposition of

compounded of the metallic part and sulphur) as it is melted out of the ore (Sect. 369.): and by the name of regulus, the pure semi-metal.

The

sulphur. In this case it resembles the common Æthiops, and is thence called *Antimonial Æthiops.*

6. Regulus of antimony readily unites with sulphur, and forms a compound of a very faint metallic splendor: it assumes the form of long needles adhering together laterally: it is usually formed naturally also in this shape. This is called *Crude Antimony.*

7. But though antimony has a considerable affinity to sulphur; yet all the metals, except *gold* and *mercury*, have a greater affinity to that compound. If therefore *iron*, *copp r*, *lead*, *silver*, or *tin*, be melted with antimony, the sulphur will unite with the metal, and be separated from the regulus, which, however, takes up some part of the metal, for which reason it is called *Martial Regulus*, *Regulus Veneris*, &c.

8. When gold is mixed, or debased by the mixture of other metals, it may be fused with antimony; for the sulphur combines with the base metals, which, being the lighter, rise up into scoria, while the regulus remains united at the bottom with the gold; which being urged by a stronger degree of heat, is freed from the semi-metal, which is very volatil. This method of *refining gold* is the easiest of all. *See note [g], to p.* 518.

9. But the most numerous purposes, to which this semi-metal has been applied, are those of the chemical and pharmaceutical preparations. Lemery, in his *Treatise on Antimony*, describes no less than 200 *processes* and *formulæ*; among which there are many good, and many useless ones. The following processes deserve to be mentioned on account of their utility.

10. Antimony melts as soon as it is moderately red hot, but cannot sustain a violent degree of fire, as it is thereby dissipated into smoke and white vapours, which adhere to such cold bodies as they meet with, and are collected into a kind of *farina* or *powder*, called *Flowers of Antimony.*

11. If

The alchemists have made great use of antimony in their experiments; some of them chiefly on account of its being found in the Hungarian gold mines. Yet still we know no more of

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11. If it be only moderately heated, in very small pieces, so as not to melt; it becomes calcined into a greyish powder destitute of all splendor, called *Calx of Antimony*. This calx is capable of enduring the most violent fire; but at last it will run into a *glass* of a *reddish yellow colour*, similar to that of the *Hyacinth*. The longer the calcination be continued, the more refractory it will be, and the less coloured the glass will become. The calcination of antimony may even be carried so far, that it will not vitrify, unless a small portion of crude antimony be thrown into the crucible.

12. The following is the best method for avoiding disappointment and perplexity in making this antimonial glass. Take any quantity of calx of antimony, made without addition, put it into a good crucible, which set in a melting furnace; kindle the fire gradually, and leave the crucible uncovered at the beginning; a quarter of an hour after the matter is red-hot, cover the crucible, and excite the fire vigorously, till the calx melts, which may be known by dipping into the crucible an iron wire, to the end of which a little knob of glass will adhere, if the matter be in perfect fusion. Keep it so for a quarter of an hour, or rather longer, if the crucible can bear it; then take it out, and pour the melted matter on a smooth stone, made hot for the purpose, or in a proper mould to give it the form of a cup, or of pills, called *Pilulæ Perpetuæ*.

The infusion made of this coloured antimonial glass, in acidulous wine (such as that of Bourdeaux) for the space of 5 or 6 hours, is a very violent emetic.

13. If equal parts of *nitre* and *regulus of antimony* be deflagrated over the fire, the grey calx which remains is called *Liver of Antimony*.

14. If regulus of antimony be melted with two parts of *fixed alkali*, a mass of a *reddish yellow* colour is produced, which being dissolved in water, and any acid being afterwards added, a precipitate

of the constituent parts of this semi-metal than the others, notwithstanding all that has been written on the subject. Some say that

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cipitate is formed of the same colour, called *Golden Sulphur of Antimony*.

15. Fixed nitre, *viz.* the alkaline salt that remains after the deflagration of nitre, being boiled with small pieces of regulus of antimony, the solution becomes reddish; and, on cooling, deposits the antimony in the form of a red powder called *Mineral Kermes*.

16. Equal parts of the *glass*, and of the *liver* of antimony, well pulverised and mixed with an equal quantity of pulverized *cream of tartar*, being put into as much water as will dissolve the cream of tartar, and boiled for 12 hours, adding now and then some hot water, to replace what is evaporated; the whole is to be filtered while hot; then being evaporated to dryness, the saline matter that remains, is the *emetic tartar*.

17. The regulus of antimony being pulverised, and distilled with *corrosive sublimate* of *mercury*, a thick white matter is produced, which is extremely corrosive, and is called *Butter of Antimony*. This thick substance may be rendered limpid and fluid by repeated distillations.

On mixing the *nitrous acid* with this *Butter of Antimony*, a kind of *aqua regia* is distilled, called *Bezoardic Spirit of Nitre*.

18. The white matter that remains from this last distillation, may be redistilled with fresh nitrous acid; and the remainder being washed with water, is called *Bezoar mineral*, which is neither so volatile, nor so caustic as the *antimonial butter*. This butter being mixed with water, a precipitate falls to the bottom, which is very improperly called *mercurius vitæ*, for it is in fact a very violent emetic.

19. But if, instead of the *regulus*, *crude antimony* be employed, and the same operation be performed; the reguline part separates from the sulphur, unites to the mercury, and produces the substance which is called *Cinnabar of Antimony*.

20. The method of making *diaphoretic Antimony* has been already described in the note [*a*] to Sect. 366. p. 792. This pre-

that its earth is not vitrifiable, becauſe it is volatile, which is perfectly contrary to experience: and if volatility be the characteriſtic of a mercurial earth, the pipe clay

preparation excites animal perſpiration, and is a good *ſudorific*. The very ſame preparation of the *diaphoretic antimony* may be more expeditiouſly made, by *one* part of *antimony* with *two and a half* of *nitre*, mixed together and deflagrated: the reſidue of which is the mere *calx of antimony*, void of all *emetic power*.

21. And if the detonation be performed in a tubulated retort, having a large receiver, containing ſome water, adapted to it, both a *clyſſus* of antimony and the antimonial *flowers* may be obtained at the ſame time, as Neumann aſſerts.

22. When nitre is deflagrated with antimony over the fire, the alkaline baſis of the nitre unites with the calx of the ſemi-metal, which may be ſeparated by an acid, and is called *Materia Perlata*.

23. It is beyond any controverſy that this ſemi-metal acts on the human body as a violent (and ſometimes virulent) emetic, and as a ſtrong cathartic, impregnating vegetable acids, as *vinegar* and *acid-wines*, with theſe virtues, almoſt inexhauſtibly. By ſulphur, and by calcination with nitre, its malignity is abated, and its emetic power changed into a diaphoretic one. But as ſoon as it is reſtored to its pure metallic ſtate, it reſumes its virulence, which may be again deſtroyed, and again reſtored, and almoſt infinitely varied.

24. Hoffman has given an account of the different medicinal and pernicious effects of antimony, as ariſing from its different modes of treatment. *Crude antimony*, on account of the *regulus*, being corrected by the *ſulphur*, is not only ſafe, but in many caſes a medicine of great ſervice, both for the human ſpecies and other animals.

25. By ſimple fuſion it acquires a degree of malignity; but a far greater one if melted with half its weight of nitre, which conſumes nearly all the ſulphur, and leaves the regulus bare.

26. Mixed with common ſalt, and calcined over a gentle fire for ſeveral hours, and afterwards edulcorated with water, it

clay from Cologne ought to be of the same nature. Perhaps it is better to say that the calx of antimony is volatile, and may both

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it yields an ash-coloured grey calx, which is so fixed as to bear a melting heat, and proves a mild and safe diaphoretic, void of any malignant or emetic quality.

27. In the same manner, if calcined with a gentle fire in an earthen vessel, uncovered and exposed to the open air, it changes into an innocent calx, without the least malignity. But if this very calx be melted with a strong fire into glass, it becomes so active, that a few grains will occasion violent vomiting and purging, or even mortal convulsions and inflammations.

28. Likewise, if the powdered regulus be calcined in a glass vial, over a sand heat, for several days, it becomes a greyish salutary diaphoretic powder. But, if reduced to regulus, by fusing it with powdered charcoal, nitre, and a little fat, it proves again virulent. Also, when antimony is melted with one fourth of its weight of salt of tartar, then powdered, the scoria separated, and the more ponderous matter pulverized, the reddish powder thus obtained is salutary; but when it is melted with three or four times its weight of salt of tartar, both the scoria and the regulus are virulent.

29. Equal parts of antimony and nitre, melted together, yield a virulent mass; but one part of antimony with 2 or 3 of nitre, makes an useful diaphoretic. The regulus melted with half its weight of nitre, continues emetic; but one part of regulus with two and a half of nitre becomes diaphoretic. Thus one preparation of antimony may be changed into another, a salutary into a poisonous, and a poisonous into a salutary one.

30. It is not yet ascertained, says Macquer, in which of the principles of antimony its *emetic virtue* resides. But it is evident, by what has been already asserted, that it cannot be ascribed to its earthy part; for the calx of antimony, when entirely deprived of all phlogiston, is not *emetic*, nor even *purgative*; as is evident from the effects of *diaphoretic antimony*, and the *pearly matter* of N° 22.

31. It is therefore equally evident, that this property of antimony depends upon the union of its metallic earth with its

be reduced into a metallic state with phlogiston alone, and melted into glass; and such is its nature, though we do not know the reason of it.

SECT. 373. (238.)

Arsenic, *Arsenicum*, Lat.

General Properties of this Semi-metal.

5. Arsenic in its metallic form,

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its phlogiston; and this appears to be the more probable; since by only re-combining phlogiston with the earth of this semi-metal, totally deprived by calcination of all its *emetic virtue*, this very virtue is perfectly restored, and the regulus thus revived is no less *emetic*, than that which never underwent calcination.

32. After all that has been related in these notes, it is no wonder that antimony had been by many esteemed an effectual poison: and by others the most extraordinary virtues, and great beneficial properties, have been attributed to the same substance. In 1566 its use was prohibited in France by an edict of the Parliament, which was repealed in 1650, antimony having a few years before, been received into the number of *purgatives*. In 1668 a new edict came forth, prohibiting its being used by any one but by the Doctors of medicine. Thus much is certain, 1st, that Antimony in its crude state is not a poison, but a medicine of great efficacy; an excellent resolvent and purifier of the animal juices, if given from 4 *grains* to half a drachm (or 30 *gr.*) together with absorbents: 2dly, that it is capable of being rendered, by various operations and additions, either truly poisonous, or more medicinal than in its crude state: and, 3dly, that its most virulent preparations may, by slight management, be made salutary; and its most salutary ones virulent and deadly poisonous, as Newmann observes. *The Editor.*

a. Is nearly of the same colour as lead, but brittle; and changes sooner its shining colour in the air, first to yellow, and afterwards to black.

b. It appears laminated in its fracture, or where broken.

c. Is very volatile in the fire, burns with a small flame, and emits very disagreeable smell, like garlick [*a*].

It

[*a*] 1. If arsenic be laid on a red-hot iron, it burns with a slight flame, white smoke, and garlick smell: is wholly volatilized, and tinges a plate of copper, held over it, white.

2. The specific gravity of the radical acid of arsenic, is = 3391; of white arsenic = 3,706; of its glassy state = 500; and of its regulus = 8,301, or even = 8,310.

3. *Aqua Regia* and muriatic acid perfectly dissolve arsenic; the *vitriolic*, however, requires to be boiling-hot. The *acetous* acid only acts upon its calx. The *nitrous* acid not only takes away as much phlogiston as may be expressed by 109; by the loss of which, the regulus is reduced to the state of a calx; but, in a large quantity, assisted by a proper degree of heat, it at length so far dephlogisticates this calx, as to leave the acid of arsenic alone.

4. From analogy it is probable, that every metal contains a *radical acid* of a peculiar nature, which, with a certain quantity of phlogiston, is coagulated into a metallic calx; but with a larger quantity, sufficient to saturate it, forms a compleat metal. *Bergman's Sciagr.* See what has been said on this subject, in the *Notes to p.* 307, 504, &c.

5. Gold, fused with arsenic in a close vessel, takes up scarcely $\frac{1}{80}$ of it; silver $\frac{1}{4}$; lead $\frac{1}{7}$; copper $\frac{5}{7}$; iron more than its own weight; bismuth about $\frac{1}{11}$; zinc $\frac{1}{7}$; regulus of antimony $\frac{1}{7}$; and manganese an equal quantity.

6. Iron, by means of less than an equal quantity of *arsenic*, loses its magnetic power. *Bergman's Sciag.* and the second vol. of his essays, p. 283.

7. The arsenic, met with in commerce, is brought chiefly from the cobalt-works in Saxony, where zaffre is made.

Arsenic

d. It is, by reason of its volatility, very difficult to be reduced, unless it be mixed with other metals. However, a regulus may be obtained from the white arsenic, if it be quickly melted with equal parts of pot-ashes and soap; but this regulus contains generally some cobalt, most of the white arsenic being produced from the cobalt ores during their calcination. The white arsenic, mixed with a phlogiston, sublimes likewise

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Arsenic is contained in great quantities in the cobalt-ores, from which it is driven off by long torrefaction: these fumes pass into, and adhere to the sides of, a very long chimney constructed for that purpose.

8. But the greatest quantities are prepared at *Geyersberg*, near the village *Ehrenfriedersberg* in Misnia, from ores brought thither from *Schneeberg*, and other Saxon mines. The ore is thrown into a furnace resembling a baking-oven, whose flew is an horizontal pipe, near an hundred fathoms in length, of a considerable width at the beginning, but growing narrower to the further end. The ore is every now and then stirred and turned over to promote the extrication of the arsenic, which arises in fumes into the pipe, and there condenses into a greyish or blackish powder, called *Meal Arsenic*. This is refined by a second sublimation in close vessels, with a little pot-ash, which detains the impurities: the force of the heat melts the sublimed flowers into the crystalline masses, which are sold all over Europe.

9. What is called arsenic is the calx of its regulus; and contains no *fixed air*. It is so far in the saline state, as to be soluble in 80 parts of distilled water in the temperature of 59 degr. of Fahrenheit; but if the water be boiling, 15 parts will dissolve one of the arsenical calx.

10. The regulus of arsenic is obtained from its calx, either by quickly fusing it after it is made into a paste, together with twice its weight of *soft soap*, and an equal quantity of mineral alkali, and pouring it out, when fused, into an hot iron cone; or by mixing it, in powder, with oil, to the consistency

likewise into octohedral crystals of a metallic appearance, whose specific gravity is 8,308.

e. The calx of arsenic, which always, on account of its volatility, must be got as a sublimation, is white, and easily melts to a glass, whose specific gravity is 5,000. When sulphur is blended in this calx, it becomes of a yellow, orange, or red colour; and according to the degrees of colour is called *Orpiment* or *yellow arsenic*, *Sandarach*, *Realgar* or *red arsenic*, and also *Rubinus Arsenici*.

This

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consistency of a syrup, and distilling the whole gradually to dryness. Towards the end, the regulus sublimes, and may be made more perfect by a second distillation in a matrass, with its own weight of oil. This operation is too offensive to be made but in the open air. After this sublimation, the matrass is broken, and a crust is found in the neck, having a glassy appearance, and a metallic lustre. This glass, exposed to the air, loses its transparency, becomes milky, and blackens sensibly.

11. The calx of arsenic is the only metallic calx that dissolves in water, and affords pyramidal crystals by slow evaporation. It unites with earths, by means of fusion, and accelerates their vitrification; but all these glasses tarnish soon by exposure to air.

Boiling oils dissolve this semi metal, as Kirwan asserts.

12. Arsenic is not attacked by *vitriolic acid* when cold; but when they are boiled together in a retort, some sulphureous acid is produced, a little sulphur sublimes, and the arsenic is found in the form of a calx, but not at all dissolved.

13. The *nitrous acid* attacks it violently, calcines it; and, by a gentle heat, a considerable part of this calx is dissolved.

According to Bucquet, the *marine acid*, assisted by heat, dissolves arsenic, and its calx.

Both fixed and volatile alkalies precipitate the arsenic from this combination.

5 The

f. This calx and glass are dissoluble in water, and in all liquids; though not in all with the same facility. In this circumstance arsenic resembles the salts, for which reason it also might be ranked in that Class, at Sect. 155.

g. The regulus of arsenic dissolves in spirit of nitre; but as it it is very difficult to have it perfectly free from other metals, it has hitherto been very little examined in various menstrua. It

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14. The regulus of this semi-metal, mixed with nitre, and thrown into a red-hot crucible, occasions a brisk detonation: but its calx, *viz. white arsenic*, does not sensibly deflagrate with nitre; and if the operation is made in an open vessel, it alkalizes the salt.

15. A mixture of arsenic and sulphur, being fused, produces either a *volatile yellow* compound, called *factitious orpin*, or *orpiment*; or a red one if the heat is brisk, called *Factitious Realgar*, *Rizegal*, or *Red Arsenic*. They are both volatile by fire, and may be decomposed by *lime*, and by *alkalis*, which have more affinity to the sulphur, than the arsenical calx. However, this *calx*, like the *acids*, may decompose the *livers of sulphur*.

16. All the properties of this calx of arsenic, prove it to be a combustible body, which, on being united to *vital air*, assumes the character of a saline substance. By distilling a mixture of *dephlogisticated marine acid* and of *calx* of *arsenic*, the *marine acid* attracts the phlogiston from the calx; and this last passes into the state of a true acid, as Scheele observed. He succeeded also in preparing arsenical acid, by distilling the calx of this semi-metal with four parts of nitrous acid. This last gives out much nitrous-gas; and the calx assumes the character of an acid in a solid form, which must be very strongly, and very long heated to disengage the superabundance of the nitrous acid. The process for disengaging this acid, which has been formerly described at p. 298, is nearly the same; and as to its properties, they have been exposed already in Sect. 161.

What

h. It is poisonous, especially in form of a pure calx, or glass. But probably it is less dangerous when mixed with sulphur, since it is proved by experience, that the men at mineral works are not so much affected by the smoke of this mixture, as by the smoke of lead; and that some certain nations make use of the red arsenic, in small doses, as a medicine.

i. It unites with all metals, and is likewise much used by nature itself to dissolve, or, as

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17. What passes in these operations seems to countenance very well the new doctrine of the *Aerial Theory.* For the calx of arsenic, by its great affinity to *pure air* (which is the radical acidifying principle of those acids), combines with it, and becomes an acid itself, in the same manner as they had been formed.

18. It was with great hesitation, that I have hitherto revolved the principles of the new theory in my mind, on account of my being deprived of the true key for unfolding the whole. But having been favoured within these few days, with the system of the *New Nomenclature*, by the generous friendship of the Authors, I can but acknowledge its great superiority (if well supported by *real facts*): and I rejoice on this valuable acquisition to the philosophical world, for explaining the operations of Nature in the most simple and intelligible way. I must keep, however, to the former language in the remainder of these notes, *ut pes et caput uni reddantur formæ*, according to the old adage of Horace.

19. The arsenical acid has a strong taste. It may be fused in the fire, and thus may be freed from the portion of the arsenical calx it happens to contain still. It weakly reddens vegetable blue colours: exposed to the air, it loses its transparency, and gradually deliquesces. This salt is soluble in two parts of water, combines easily with *lime*, but more difficultly with *ponderous* and *magnesian* earths. It forms neutral salts, when united to alkalis, which, however, may be decomposed by *lime*, as Bergman asserts.

The

as we term it, to *mineralise* the metals, to which its volatility, and solubility in water, must greatly contribute. It is likewise most generally mixed with sulphur.

k. It absorbs, or expels, the phlogiston, which has coloured glasses; if mixed with them in the fire.

SECT. 374. (239.)

Native Arsenic.

Arsenic is found,

1. Native, *Arsenicum nativum*; called *Scherbencobolt* and *Fliegenstein* by the Germans.

It is of a lead colour when fresh broken, and may be cut with a knife, like compact black lead, but soon blackens in the air. It burns with a small flame, and goes off in smoke.

A. Solid and testaceous, *Arsenicum nativum particulis impalpabilibus testaceum. Scherbencobolt* [a].

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20. The acid of arsenic, by the addition of any phlogistic substance, becomes white arsenic; and, by the addition of still more, assumes the appearance of a perfect semi-metal, though apparently no states are more opposite than those of a liquid acid, and of a solid metallic substance. *The Editor from* Kirwan, Bergman, Fourcroy, &c.

[a]. The *regulus of arsenic* is found with a metallic form, in Bohemia, Hungary, Saxony, Hercynia, and else where, but particularly at St. *Marie aux mines*, in Alsatia, where not long since many hundred weight of it were extracted. In Germany

This is found in the mines of Saxony, the Hartz, and Hungary.

B. *Scaly, *Particulis micaceis*, from Winorn at Kongsberg in Norway.

C. Friable and porous, *Friabile et porosum.* *Fliegenstein*, in German [*b*].

With

Germany it is called not only *Fliegstain*, but also *Mucken-pulver*, viz. *flie-powder*; although it is difficult to guess for what reason this last name has been given to it, as this regulus is not soluble in water: and therefore, unless dephlogisticated, it is not at all proper for the purpose alluded to by such a name. Perhaps by some spontaneous calcination it became, one time or another, so much dephlogisticated as to acquire a degree of solubility, which answered to that purpose.

As to its form, it is often found shapeless, friable, and pulverulent; but sometimes compact, divided into thick convex lamellæ, with a needle-formed or micaceous surface. It admits of a polish, which, however, is soon lost by it's being exposed to the action of the air.

When fresh broken, it appears as if composed of small needle-like fibres, of a leaden colour, which soon grows yellow, and by degrees blackish. In hardness it seems to exceed copper, and in brittleness it resembles antimony. *Bergman, Dissert.* 21. § 11.

The native regulus of arsenic is seldom, if ever, found in a crystalline form, and possessing all the properties of the arsenical regulus. It is sometimes found mixed with various metals; and, it may be analysed by solution in *aqua regia*. The silver, if any, will remain precipitated: the iron, of which it commonly contains a small portion, will remain in the solution; and if a small quantity of water be added after decantation, the calx of arsenic will be precipitated, and the iron will remain. The Editor from Kirwan.

[*b*]. Some of the proper ores of arsenic are of a *whitish*, and others of a *blackish* colour; and both sorts have more or less of a sparkling aspect; the first are called *White Pyritæ*, or *Mispickel*, the latter *Fliegenstainertz*. They consist mostly of

1. With shining fissures, *Fissuris nitentibus*, from Annaberg in Saxony.

This is by some called *Spigel Cobolt* (*Minera cobalti specularis*) according to their notions of the affinity of these metals to one another. However, there always remains after the volatilisation of the Scherbencobolt, some calx, either of cobalt or bismuth, and some silver, though in too small a quantity to deserve any notice.

SECT. 375. (240.)

Calciform Arsenical ore.

2. In form of a calx, *Arsenicum calciforme*.

A. Pure, or free from heterogeneous substances, *Calx arsenici nativa pura* [a]

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of arsenic, blended with a considerable proportion of earthy or stony matter, but with little, if any, mixture of any other metallic body, *Newmann*, p. 226.

[a] This calciform ore is a true mineralisation of this semi-metal by the aerial acid.

It is called also Native *Calx of Arsnic*, and *Flos Arsenici* by some mineralogists.

It does not detonate with nitre, though an effervescence arises.

Its specific gravity is from 3,706 to 5000.

Is soluble in about 70 or 80 times its weight of water in the temperature of 60 *degr.* of Fahrenheit's thermometer.

But in boiling water, 15 or 20 times its weight are sufficient to dissolve it.

The solution turns tincture of turnsole *red*: and syrup of violets *green*.

It is scarcely soluble in the *vitriolic* acid; something more in the *marine*, and most perfectly in the diluted *nitrous* acid. *The Editor from* Kirwan.

Loose

1. Loose or powdery. This sort is found at Giesshubel in Saxony, but it is collected in a much purer state on the sides of the rock in some mines.
2. Indurated or hardened. This is found in form of white semi-transparent crystals, in small cavities within the Scherbencobolt, at Andreasberg in the Hartz, and in Saxony, but it is very scarce.

SECT. 376. (241.)

Sulphurated Arsenic. Orpiment. [a].

A. Mixed with sulphur, *Calx arsenici sulphure mixta.*

1. Hardened.

a. Yellow. Orpiment, *Auripigmentum,* from Hungary [b].

Red,

[a] The orpiment may perhaps be found naturally in loose scaly powder, as it is sometimes met with in the shops. However, I have only seen the hardened sort in collections. *The Author.*

[b] Orpiment is naturally found in the earth; in general it is amorphous, and very seldom crystallized. Baron Borne once found it in a polyhedral form on a blue clay in Hungary.

It is generally composed of shining, flexible laminæ like *mica,* more or less solid.

Its specific gravity is about 5,315. It burns with a blue flame, and contains only about *one tenth* of its weight of sulphur.

Some pretend that orpiment, on account of the sulphur it contains, has no poisonous qualities, and may safely be *b*. Red, Native Realgar or Sandarach, from Hungary, Andreasberg in the Hartz, Saxony, and Rotendal in Elfdalen in Sweden [*c*].

SECT. 377. (242.)

Arsenic mixed with metallic calces.

C. Mixed with the calx of tin, in the tin-grains. Sect. 299, (181) and 301.

D. With sulphur and silver, in the Rothgulden, or red silver ore, Sect. 270 and the 5 following.

E. With calx of lead, in the lead-spar. Sect. 308.

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be used internally; but Maquer very possitively asserts the contrary, and gives a very serious warning against its use, even if the orpiment be truely native. *The Editor from* Fourcroy *and* Kirwan.

[*c*] The *red-arsenic*, or *realgar*, called otherwise *Rawschgelbe* by the Germans, is found in irregular, or stalactitical masses.

It is either opake, or semi-transparent; sometimes it is found transparent, and regularly crystallized in octohædral pyramids, or prisms; in this last form it is called *Ruby of Arsenic*.

Its specific gravity is = 3,225.

It contains 16 parts of sulphur *per* hundred weight.

Nitrous acid soon destroys its redness.

To analyse these ores, they should be digested in *marine acid*; adding the *nitrous* by degrees to help the solution. The sulphur will be found on the filter; and the arsenic will remain in the solution, from which it may be precipitated in its metallic form by zinc, adding spirit of wine to the solution. *The Editor from* Kirwan.

F. With calx of cobalt, in the efflorescence of cobalt. Sect. 384.

SECT. 378. (243.)

Mineralised Arsenic.

3. Mineralised arsenic, *Arsenicum mineralisatum.*

A. With sulphur and iron, *Arsenicum ferro sulphurato mineralisatum.* Arsenical pyrites or marcasite [*d*].

This alone produces red arsenic, in roasting: and is found in great quantities in the mines of Lofas in the province of Dalarne. It is of a deeper colour than the following.

B. With iron only, *Arsenicum metalliforme ferro mixtum. Mispickel* [*e*]. This differs with regard to its particles, being

1. Steel-grained;
2. Coarse-grained, from Westersilverberget;

[*d*] These kinds in Cornwall are called Silvery or White Mundics, and Plate Mundics. *D. C.*

[*e*] The mineral, commonly called *Mispickel*, is justly reckoned a regulus of arsenic, as, when totally deprived of sulphur, it consists of iron and arsenic united in a metallic form: and although the iron amounts to $\frac{1}{}$, or sometimes even to $\frac{2}{3}$, yet the compound is not *magnetic*, but if ignited, sends forth an arsenical smell, and is soon rendered magnetic, though the operation be performed on a tile, without any phlogiston. See note *d* to p. 741. It easily flows in the fire; and, in close vessels, the greater part of the regulus rises, leaving the iron to the bottom. A compound of this kind may also be artificially made. *Bergman*, De Arsenico, § 2.

Crystallized

3. Criſtalliſed.

a. In an octohedral figure. This is the moſt common kind.

b. Priſmatical, from the mines of Salberg, Weſterſilfverberget, and Hellefors in Weſtmanland, and in many places of foreign countries [f].

SECT. 379. (244.)

Arſenic Mixed with metals.

C. With cobalt, in almoſt all cobalt ores. Sect. 382. 384. and 386.

D. With ſilver. Sect. 271 and following.

E. With copper. Sect. 327.

F. With antimony. Sect. 370.

SECT. 380. (245.)

OBSERVATIONS on ARSENIC [g].

Such ores as conſiſt of arſenic united ſolely with iron, or with iron and ſulphur, cannot be

[f] The ſulphureous marcaſite is added to this kind, when *red arſenic* is to be made; but in Sweden it is ſcarcer than the ſulphureous arſenical pyrites. *The Author.*

[g] 1. It can hardly be doubted, that arſenic may be applied to valuable purpoſes in medicine; as various experiments have proved in different applications. But, in reſpect both

be employed to any other use than to the preparation of arsenical products; for which reason they ought to be ranged among the arsenic ores. Some have indeed denied this difference between the arsenical pyritæ; but it is however necessary to make some difference, with respect to the presence or absence of sulphur, although the greatest quantity of arsenic is got from the calcination of the cobalt ores, and that the true arsenical pyritæ do not deserve to be separately employed.

Although

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both to its dose and preparation, the utmost caution must be used, for it is beyond any dispute that arsenic is the most virulent of all poisons, and that, even when externally applied, it often produces very pernicious effects.

2. Phlogiston and alkalis seem to be the best correctors of the corrosive acrimony of arsenic; and may be applied to obviate its deleterious effects. It was thought of course, that the *neutral arsenicated salt* of Macquer, being saturated with the vegetable alkalis, would not produce those noxious effects; but Mr. de Morveau asserts, that upon trial this neutral salt is in fact a very stupifying poison.

3. Hence too it appears, says Bergman, why *realgar* is less noxious, why the regulus is milder than white arsenic, and this again milder than the *dry acid:* why the baths of *Carlsbad*, which contain a *mineral alkali* only, united with aërial acid, are extremely useful in diseases occasioned by arsenic: why *arsenic*, taken internally without the necessary correction, occasions, by its irritating quality, convulsive motions, among other symptoms, both in the stomach and other parts of the body.

4. Of all metals arsenic most easily loses its phlogiston; we therefore should be cautious in confiding to phlogistic correctors, as the phlogiston may be separated in the viscera by many different ways.

5. The symptoms of such as in a fit of despair, have taken a dose of arsenic, begin to appear in about half an hour

Although it is difficult to reduce the arſenic by way of precipitation, one cannot for that reaſon deny it to be of a metallic nature; for the ſame reaſoning might have been uſed againſt the exiſtence of zink in the calamine, before the method to extract that ſemi-metal in its metallic ſtate, now known, was diſcovered. But thoſe who know that metals only can be mixed with metals, ſo as to preſerve the ſolidity and ſome ductility in the compound, and who at the ſame time are ignorant of any metallic earth which cannot be reduced to its metallic ſtate again, could never entertain ſuch notions.

It is indeed true, that ſulphur, in regard to the brittleneſs which it produces in metals, is of

hour after, by a nauſea, ſickneſs, and reaching; theſe are followed by violent vomitings, hiccups, and pains in the ſtomach and bowels: convulſions and palſies in the limbs, intenſe heats, cold ſweats, and palpitations of the heart, extreme anxieties, reſtleſsneſs, proſtration of ſtrength, thirſt and dryneſs of the mouth and throat, loſs of reaſon, and at laſt death. If the quantity taken has been conſiderable, the ſtomach and inteſtines are found, upon diſſection, corroded and perforated; though in general the patient expires before the further action of the poiſon can take place: and the moſt experienced phyſicians acknowledge, that no antidote can overcome the deſtructive efficacy of this poiſon.

6. A preparation of arſenic with nitre has been once highly extolled, as a febrifuge, at Berlin; but arſenic, however prepared, continues to retain its poiſonous quality. Even the external application of this ſubſtance has produced many times the moſt dangerous conſequences: and Doctor Mead has ſhewn that the uſe of arſenic, as an antipeſtilential preſervative

of no worse effect than arsenic; but this last may by itself, and mixed only with a pure phlogiston, be sublimed into a metallic form, which is more plainly seen in the Scherbencobolt (Sect. 374.). I easily perceive that it may be objected by those who deny arsenic to be a semi-metal, that it may as well be a salt of a peculiar nature; as, for instance, the vitriolic acid is; and that it may, like sulphur, dissolve the metals in form of a kind of regulus; and farther, that its assuming a metallic appearance, when it is united with an inflammable substance, is of no consequence; since there are fish and insects who have a shining metallic colour: to this little can be answered, since it has been already agreed, that systems must not be too severely criticised.

SECT.

servative among the Arabians, is grounded on a mistake of the word *darsini*, which is nothing else but a preparation of cinnamon with other aromatics, &c.

7. The *philothrum Turcicum*, or pomatum of Turky, contains orpiment, among others substances; but its depilatory power is perhaps more properly ascribed to the caustic alkali.

8. Philosophers evince the extraordinary porosity of bodies, and the wonderful subtility of vapours, by the sympathetic ink. This is composed of *caustic fixed alkali*, boiled in water with orpiment, which yields a foetid hepatic solution, in which state it is used as such. Orpiment, also, boiled in water, with double the weight of quicklime, affords a *probatory liquor*, which may be employed for proving wines; for when they are naturally acid, or grown so by age, the owners still dare to continue to edulcorate them, with sugar of lead; notwithstanding the punishment of the law, if detected; but some drops of this probatory liquor being thrown into a

glass

SECT. 381. (246.)

6. Cobalt. *Cobaltum.*

Its general properties [a].

6. This semi-metal is,

a. Of a whitish grey colour, nearly resembling fine hardened steel.

Is

glass of suspected wine, if it is adulterated, a *brown* or *black sediment* will be precipitated: otherwise, if the wine is pure, it will occasion nothing but a *yellow precipitate.*

N. *B.* A large proportion of tartar in the wine, will render the probatory liquor ineffectual; as the tartarous acid will form with the lime a *white salt*, very difficult of solution.

Mountain-crystals placed over *orpiment*, *white arsenic*, *crude antimony*, and *sal ammoniac*, mixed in a crucible, are tinged by means of heat, with a beautiful red, yellow, and *opal colours*, as Neri has described; but they very often crack in the operation.

In painting likewise the artists employ arsenic. Painters in oil, frequently use *orpiment* and *realgar*, and a beautiful *green* pigment may be precipitated from blue vitriol, by means of white arsenic dissolved in water, together with vegetable alkali. This, prepared with water or oil, affords a colour which suffers no change in many years; but must not be applied to any kind of sweetmeats, or food, as it is really very poisonous. *The Editor from* Bergman, Kirwan, &c.

N. B. Arsenic whitens fused copper. *See note* [*b*], *p.* 711.

[*a*] The colour of regulus of cobalt is rather of a blueish grey; and its specific gravity is about = 7,700.

Its fusibility is like that of copper, or even gold; and, when well purified, it is hardly easier to melt than iron.

If melted cobalt is slowly cooled, it crystallises, forming in its surface small bundles of needles, or needle-form prisms,

 laid

b. Is hard and brittle, and of a fine grained texture; hence it is of a dusky, or not shining appearance.

c. Its specific gravity to water is 6000 :: 1000.

d. It is fixed in the fire, and becomes black by calcination; it then gives to glasses a blue colour, inclining a little to violet, which colour, of all others, is the most fixed in fire.

e. The concentrated oil of vitriol, aqua fortis, and *aqua regia*, dissolve it; and the solutions become red. The cobalt calx is likewise dissolved by the same menstrua, and also by the volatile alkali, and the spirit of sea-salt.

When

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laid on one another, and united into bundles. Mongez observed, that they greatly resemble a mass of shaken basaltes.

In order to succeed in this crystallization, it is sufficient to fuse cobalt in a crucible, till it suffers a kind of ebullition; and, after having taken it from the fire, to incline the vessel, while the surface of the semi-metal is congealing. By this inclination the portion still fused is poured out, and that which adheres to the sides of this kind of geode, formed by the cooling the surfaces of the cobalt, is found covered with the crystals sought for.

Melted with borax it affords a *blue* glass, which is the most obvious property for distinguishing its ores amongst all others.

It is difficultly calcined; and

Its calx, although it appears black, is in fact of a very deep blue.

This calx is not volatil; and being melted with borax, or potash, and siliceous sand, it produces a blue glass, called *smalt*.

The regulus of cobalt is easily soluble in *spirit of nitre*, and *aqua regia*,

 The

f. When united with the calx of arſenic in a ſlow (not a briſk) calcining heat, it aſſumes a red colour. The ſame colour is naturally produced by way of efflorescence, and is then called the *bloom* or *flowers of cobalt.* When cobalt and arſenic are melted together in an open fire, they produce a blue flame.

g. It does not amalgamate with quickſilver by any means hitherto known.

h. Nor does it mix with biſmuth, when melted with it, without addition of ſome medium to promote their union.

The colour of this ſolution, as well as that made in any of the other acids, and in *volatil alkali*, is either *red* or of a *roſe-colour.*

This ſolution, diluted with water, is a ſympathetic ink, as the writing with it does not appear when dry; but, on being moderately warmed, it becomes of a fine green colour.

Its precipitate, by common or phlogiſticated alkali, is of a reddiſh-aſh colour.

It difficultly diſſolves in *vitriolic* acid; and ſcarce at all in the *marine*, unleſs heat be employed. The *marine* ſolution is a ſympathetic ink, and it is on account of the *marine* part in the *aqua regia*, that the above ſolution has the ſame property.

The calx, however, of this ſemi-metal is more eaſily diſſolved by theſe acids, and yields even to the *acetous* acid.

It is worth notice that the red colour of the acid ſolutions of cobalt when diluted with water, inſtead of fading, ſeems to become more vivid.

Cobalt does not combine by fuſion with ſilver, biſmuth, or lead.

It is moſt ſtrongly attracted by the acid of ſugar, which precipitates it from the other acids, in the form of a pale roſe coloured powder.

The acid of ſorrel, alſo precipitates cobalt from the muriatic and other acids. *The Editor from* Bergman, Kirwan, *and* Fabroni.

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SECT. 382. (249.)

Native Cobalt [*b*].

B. 1. With arsenic and iron in a metallic form, *Cobaltum ferro & arsenico metalliformi mineralisatum*; *vulgò* Cobaltum *dictum*.

This

[*b*] Pure native cobalt has not yet been found: that which passes for such, according to Kirwan, is mineralized by arsenic. Bergman, however, in his *Sciagraphia*, has entered this present ore, under the denomination of *native cobalt*: and certain it is, that among all the cobaltic ores, this is the nearest to the *native* state of this semi-metal. It always contains a small quantity of iron, besides the arsenic, by which it is mineralized.

This is generally called the *Grey Cobalt Ore*, and Glantz-cobalt, or *Stahl Derben Cobalt*, by the Germans; and, besides the places mentioned by the author, it is also found in some parts of England, particularly at Mendip Hills in Somersetshire, and in Cornwall, in which last country Dr. Lewis asserts it to have of late been dug out in considerable quantities. Klaproth, in his account of the fossils of Cornwall, asserts, that at Dolcoth in this last country, the grey cobalt ore is found either without, or with bismuth; he adds, that it resembles very much in colour, fracture, and other external appearances, the cobalt-ores from Rappold at Schneeberg, in the district of Misnia in Saxony: and having made various and repeated trials of these English cobaltic ores, he found them to produce the finest blue colours, when properly vitrified.

An arsenicated grey cobalt ore, combined with galena, was found also in the year 1783, by Mr. Brolman, at Chateaudren; as it is asserted in *Journal, de Physique* for Sept. 1787, p. 177.

This

This is of a dim colour when broken, and not unlike ſteel. It is found

a. Steel-grained, from Loos in the pariſh of Farila, in the province of Helſingeland, and at Schneeberg in Saxony.

b. Fine grained, from Loos.

c. Coarſe-grained.

d. Criſtalliſed.

1. In a dendritical or arboreſcent form, from Schneeberg.
2. Polyhedral, with ſhining ſurfaces; the *Glantzkobolt* of the Germans, from Schneeberg.
3. In radiated nodules, from Kongſberg in Norway.

SECT.

This ore is of a ſolid, heavy, and compact texture. Sometimes of a dull, and ſometimes of a bright appearance; frequently cryſtallized in a teſſelar, and ſometimes in a dendritical form,

And in general is ſo hard as to give fire with ſteel; and an arſenical ſmell is then perceived.

It grows black in the fire; is ſoluble with effervescence in *nitrous acid*, from which it may be precipitated by the *marine*; and affords the ſympathetic ink, mentioned already in the notes to Sect. 381.

In order to diſtinguiſh this from the arſenical ores of the ſame appearance, the two principal characters of cobalt, *viz.* the ſympathetic ink, and the blue colour given to glaſs, are fully ſufficent.

It is analyſed by ſolution in *aqua regia*, or *nitrous acid*, and evaporation to dryneſs. The reſiduum treated with the acetous acid will yield to it the cobaltic part; but the arſenic ſhould be firſt precipitated by the addition of water.

Or elſe this ore may be firſt roaſted to expell the arſenic; and then if treated with *nitrous acid*, the cobalt will be diſſolved with the ſmall portion of iron; and, by boiling the ſolution,

SECT. 383. (247.)

Calciform Cobalt [a].

The cobalt is most commonly found in the earth mixed with iron.

A. In form of a calx, *Cobaltum calciforme.*

1. With iron without arsenic, *Martiale absque arsenico.*

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solution, most of the iron will be precipitated: by adding fixed alkali, the remainder of the iron will be first precipitated *yellowish*, and afterwards the cobalt will fall down of a reddish colour.

The Prussian alkali may also be employed, to precipitate first the *iron* of a blue colour, and afterwards the cobalt *reddish*, or rather *grey*. The Editor from *Bergman*, *Kirwan*, *Mongez*, &c.

[a] This ore seems to be the aerated cobalt of Kirwan, p. 336 of his *Elem. of Minerology.*

It is called the *Black Ore of Cobalt*, *Vitreous Ore*, Kobalt Mulmum, and Schlaken-Kobalt, by the Germans.

It is found in a loose, powdery form Sometimes resembling *lamp-black*, either grey or blackish, and then called *Cobalt Ochre.*

When in black indurated scoriform masses, it is called *Schlaken Kobalt*, or Vitreous Cobalt. They are free from sulphur and arsenic; and if these be present, they are only mechanically mixed.

A small portion of copper and iron is also sometimes found in it.

This ore is frequently imbodied in stones, or sands of a black colour. Talc, chalk, and gypsum, impregnated with it, are called by the same name; and by some *Spiegel Cobalt.* It is sometimes also contained in some green and blue earths of the argillaceous kind. *Kirwan*, p. 336.

Loose

a. Loose or friable, *Minera cobalti calciformis pulverulenta*. Cobalt ochre, *Ochra cobalti nigra*. It is black, and resembles the artificial zaffre.

b. Indurated, *Minera cobalti calciformis indurata*. *Minera cobalti vitrea*, the *schlacken* or slag cobalt.

This is likewise of a black colour, but of a glassy texture, and seems to have lost that substance which mineralised it, by being decayed or withered. It is often confounded with the Scherbencobolt, for it is seldom quite free from arsenic; and there may perhaps exist a progressive series from the Schlacken kind to the Scherbencobolt kind (of Sect. 374.).

SECT. 384. (248.)

2. *Combined with Arsenical Acid* [d].

This ore is the *Minera cobalti calciformis acido arsenici mixta*: or *Cobalt-blut*.

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[d] This ore is found also either *loose* and *pure*; or mixed with *chalk* or gypsum; or indurated and crystallized in tetrahedral crystals; or in a stalactictical form.

It melts easily, and then becomes blue.

It frequently invests other cobaltic ores: and is found sometimes in stone and sand. Bergman has shewn that the arsenical *acid*, and not the *calx* of arsenic, as the text erroneously expressed, enters into this combination; for cobalt is never *red* but when united to an acid. Kirwan, p. 337.

Flowers of cobalt, mineralized by arsenic, without any silver, and intermixed with galena, were discovered, on the mountain near the village of Aténe, by Mr. Schreiber. See Journal de Physique *for September* 1787, p. 177.

Ochra

Ochra cobalti rubra, Bloom, Flowers, or Efflorescence of cobalt.

a. Loose or friable, *Ochra cobalti pulverulenta*. This is often found of a red colour like other earths, spread very thin on the cobalt ores: and is, when of a pale colour, erroneously called Flowers of Bismuth [e].

b. Indurated, *Ochra cobalti rubra indurata*. Hardened Flowers of Cobalt.

This is commonly cristallised in form of deep red semi-transparent rays or radiations: It is found at Schneeberg in Saxony.

SECT. 385. (250.)

Cobalt with sulphurated iron, Cobaltum ferro sulphurato mineralisatum [f].

This ore is of a lighter colour than the preceding, nearly resembling tin or silver. It is found,

[e] A white cobalt-earth, or ochre, is said to have been found. It has been seen and examined by a celebrated mineralist, who found it in every respect, except the colour, to resemble the cobalt flowers; and it is very possible, that those cobalt flowers might in length of time have lost their red colour, and become white. *The Author*.

[f] This ore is sometimes found in large masses, and sometimes in grains crystallised, of a dull white colour, and frequently bears the appearance of *Mispickel*. It has no mixture of arsenic.

It becomes *black*, and not *red*, by calcination, which distinguishes it from pyrites. And it contains so little sulphur that none can be extracted from it.

When dissolved in *aqua regia* its solution is *yellow* while cold, but when boiling becomes *green*, which alternation of colour is peculiar to *marine cobalt*. The Editor from Kirwan, p. 349.

a. Crystallised

a. Cryſtalliſed.

1. In a polygonal form.

a. Of a flaggy texture.

b. Coarſe-grained.

This kind is found in Baſtnasgrufva at Raddarſhyttan in Weſtmanland, and diſcovers not the leaſt mark of arſenic. The coarſe-grained becomes ſlimy in the fire, and ſticks to the ſtirring hook during the calcination in the ſame manner as many regules do. It is a kind of regule prepared by nature.

That ſort which is of a flaggy texture is very martial, and is deſcribed by the mine-maſter Mr. Brandt, in the Acts of the Swediſh Academy of Sciences for the year 1746. Both theſe give a beautiful colour.

SECT. 386. (251.)

Combined with ſulphurated and arſenicated iron [g].

3. With ſulphur, arſenic, and iron, *Cobaltum cum ferro ſulphurato et arſenico mineraliſatum*.

[g] This ore has a great reſemblance to the *Stahl derben Kobalt*, mentioned in the note to Sect. 382: but it is ſofter, for it never ſtrikes fire with ſteel, and may ſometimes even be ſcraped with a knife.

It moſtly appears under ſome polygonal form.

The moſt ſhining ſorts of this ore, and of the former ſpecies, have been called *Cobalt Glantz*.

It is analyſable like the other cobalt ores, and the ſulphur may be caught in the filter. Kirwan, p. 339.

This

This resembles the arsenicated cobalt ore, being only rather of a whiter or lighter colour. It is found

a. Coarse-grained.

b. Crystallised.

1. Of a polygonal figure, with shining surfaces, as the *Glanzkobolt* pag. 827.

It occurs at Tunaberg in the province of Sodermanland, partly of a white or light colour, and partly of a somewhat reddish yellow.

SECT. 387. (252.)

4. With sulphurated and arsenicated nickel and iron.

See *Kupfernickel* in Sect. 256 of the Author

SECT. 388. (253.)

OBSERVATIONS on COBALT [*h*].

Since the glass of cobalt, which has been entirely freed from all arsenic in the calcination,

[*h*] The great consumption to which cobalt is employed, consists only in the application of the permanent blue colour it affords to glasses and enamels, either upon metals, or on porcelains, and earthen wares of all kinds. It is also the same *blue*, prepared in a very cheap way by the Dutch, from the coarse zaffre, or blue glass of cobalt chiefly, and called *Azur de Hollande* by the French, which is employed by laundresses. But, although cobalt is applied to hardly any other purposes, these alone render very profitable this semi-metal to the happy possessors

tion, and from the iron and the other metals by ſcorification, as when it is prepared from criſtalliſed cobalt flowers, may by addition of phlogiſton be melted to a true cobalt regulus, which differs in its qualities from all other metals; there can be no reaſon for denying the cobalt a place among the ſemi-metals, as many authors even at this time do, notwithſtanding the ſeveral reaſons given; which might induce them to examine nearer into the ſubject.

It was the Mine-maſter Mr. Brandt who firſt diſcovered this ſemi-metal, and deſcribed it in the abovementioned Hiſtory of Semi-metals, in the *Acta Upſalienſia* for the year 1735.

The

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poſſeſſors of its mines, if they are productive enough of its ore, to be worked on a large ſcale.

Ores of cobalt are found in ſeveral parts of Europe; the moſt plentiful are worked near Schneeberg, in the diſtrict of Miſnia in Saxony; alſo at St. Andreaſberg in the upper Hartz, where large quantities have been met with for upwards of 30 years paſt. Some centuries ago there was but an iron ore in this laſt place; but, about the beginning of the fourteenth century, on ſinking deeper, it was ſucceeded by a very rich ore of ſilver. This alſo being at length exhauſted, gave place to cobalt-ores. Some pieces are ſometimes found in theſe mines that contain ſilver and gold. Theſe metals, however, are only accidental, and not eſſential, as ſome raſhly ſuppoſe, to the exiſtence of cobalt ores.

The general method of preparing cobalt ores in the large way ſeems confined to Saxony alone, from whence all other parts of the world, even the Eaſt-Indies, are conſtantly ſupplied. It is ſuppoſed that the Chineſe and more particularly the Japaneſe, had formerly mines of excellent cobalt, with which

The brittleness of the cobalt regulus is no proof against its being a semi-metal; that property being the basis on which the distinction between the semi-metals and metals is founded. The earth of cobalt is fixed and vitrifiable in the fire, as well as that of copper and iron; and the colour of its glass being so immutable in the fire, proves it to be a particular substance, distinct from other earths and metallic calces.

The experiment of making a cobalt glass from iron or steel and arsenic, will certainly never succeed, unless the arsenic, employed for that purpose, has been made from a cobalt ore; but if the origin of the colour should be ascribed

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the fine blues of their ancient porcelanes were painted; but it appears that these mines are now exhausted; and that the inferior blues of their present wares are painted with the Saxon zaffre, imported to them by the Dutch.

In regard to the management of this article at large, as employed in Saxony, the following is the abstract. The cobalt taken out of the mine, is broken with hammers into pieces, about the size of an hen's egg; and the stony involucrum, with such other heterogeneous matters as are distinguishable by the eye, are separated as much as possible. The chosen mineral is then pounded in stamping mills, and sifted through brass wire sieves. The lighter parts are washed off by water, and it is afterwards calcined in a large flat-bottomed arched furnace, resembling a baking oven, where the flame of the wood reverberates upon the ore: this is occasionally stirred and turned during the calcination, with long handled iron hooks or rakes; and the process is continued till it ceases to emit any fumes. The oven or furnace is terminated by a long horizontal gallery, which serves for a chimney; in which the calx of arsenic, naturally mixed with the ore, sublimes, condenses, and is fused into a glass, which is sold, in ascribed to an irreducible metallic earth, there is no occasion for this experiment; because a cobalt regulus may be prepared so as to be free both from arsenic and iron, the presence of this last metal being easily discovered by the loadstone.

It is therefore now unnecessary and ridiculous to continue the old definitions of the cobalt, in which the Speise, which partly is a cobalt regulus, and partly a compound, consisting of nickel, cobalt and bismuth, united with sulphur and arsenic, is either confounded with the semi-metal itself, or quoted as a proof, that cobalt regulus cannot exist in any other manner than as a dead earth involved in heterogeneous

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in commerce, by the improper name of *White Arsenic*. If the ore contains a little *bismuth*, as this semi-metal is very fusible, it is collected at the bottom of the furnace. The cobalt remains in the state of a dark grey calx called *zaffre*. One hundred pounds of the cobalt ore lose 20 and even 30 *per cent.* during this operation, which is continued 4 or even 9 hours, according to the quality of the ore. The roasted ore being taken out from the furnace, such parts as are concreted into lumps, are pounded and sifted afresh. This roasted powder of cobalt is the true zaffre. But the zaffre in the commerce is never pure, being mixed with two. or rather three parts of powdered flints. A proper quantity of the best sort of these, after being ignited in a furnace, are thrown into water, to render them friable, and more easily reduced to powder, which, being sifted is mixed with the zaffre, according to the before-mentioned dose: and the mixture, is put into casks, after being moistened with water. This is the substance commonly sold under the name of *zaffre*.

As to *smalt* it is no more than a vitrification of one part of the *calcined cobalt*, fused in a large crucible with two of *flint-powder*, and one of *pot-ash*.

heterogeneous substances; which is the same as to conclude, that no pure copper can be produced from the copper regules or fusions, called *Trottsten* or *Spursten*.

These false notions have, however, induced a late author to describe the cobalt as a mixture of iron, copper, lead, bismuth, and arsenic; but he has not at the same time published any experiments which might serve to confirm his opinion; amongst which, with great reason, such experiments are expected as imitate nature in this composition, which is pretended to consist of so many different things. It might then have been calculated, whether it would be profitable to establish manufactures for making

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At the bottoms of the crucibles in which the *smalt* is manufactured, is generally found a regulus of a whitish colour, inclining to red, which is extremely brittle. It is melted afresh, and when cold it separates into two parts; that at the bottom is the cobaltic regulus, which is employed to make more of the smalt by the process already described: and the other at the top is bismuth: for those two semi-metals are found very often mixed in the natural ores.

But to assay ores of cobalt in small quantities, by the dry way, it is enough to free them carefully from their matrix, and from all other heterogeneous matters: after which they are pounded, sifted, and washed: their sulphur is separated by roasting: and lastly they are to be melted with three parts of *black flux*, in a lined and covered crucible, on a smith's forge. The best of these ores afford from 60 to 80 *per cent* of *regulus*; and the worst under 25 *per cent*.

To assay the tinging power of cobaltic ores, the roasted ore is to be melted in a crucible with 3 times its weight of *pot-ash*, and 5 times of pounded glass, or prepared flint. The ing cobalt-glafs, or zaffre, in any part of the world, where the abovementioned ingredients can be had.

The word Cobalt in Germany, and efpecially at the mineral works in Saxony, is applied to the damps, the arfenic, its vapours, and their effects on man; which has induced the vulgar alfo to apply it to fome pretended evil fpirit, which is faid to dwell in the mines. But time will abolifh thefe fuperftitions, which have their origin in ignorance.

SECT. 389. (254.)

1. Nickel. *Niccolum.*

Its general properties [a].

This femi-metal was firft defcribed by its difcoverer Mr. Cronftedt in the Acts of the

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The *pot-afh* is to be put in firft, then the *glafs* or *flint*, and over all the *ore*.

If any bifmuth be contained in the cobalt ore, it will not mix with the regulus of cobalt, unlefs nickel be alfo contained in it, but will fimply adhere to it; and may be feparated by the hammer, or by fufion; for the bifmuth melts much more eafily than cobalt.

When cobalt is united by means of nickel to bifmuth, the compound is called *Speifs*. This is the name given alfo to a compound of *cobalt*, *nickel*, *bifmuth*, *fulphur*, and *arfenic*. The Editor from *Kirwan*, p. 340 and *Lewis*, &c.

[a] 1. Nickel is a reddifh-white femi-metal of great hardnefs, fo that it can fcarce be filed.

2. Its texture is equable, or uniform; and

3. It varies in its fpecific gravities, according to its purity; from 7421 to 9000; the pureft being the heavieft.

 4. When

Royal Academy of Sciences at Stockholm, for the years 1751 and 1754, where it is said to have the following qualities: That

1. It is of a white colour, which however inclines somewhat to red.
2. Of a solid texture, and shining in its fracture.
3. Its specific gravity to water is as 8,500 :: 1,000.
4. It is pretty fixt in the fire; but together with the sulphur and arsenic, with which its ore abounds, it is so volatile, as to rise in form of hairs and branches, if in the calcination it is left without being stirred.
5. It calcines to a green calx.
6. This calx is not very fusible, but it however tinges glass of a transparent reddish brown, or hyacinth colour.
7. It dissolves in aqua fortis, aqua regia, and the spirit of sea-salt, but more difficultly in the vitriolic acid, tinging all these solutions

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4. When very pure, it is in some degree malleable; and

5. Is always magnetic; from whence it is deemed to retain iron, though this seems to be rather a property belonging as well to itself, because it appears to increase with its depuration.

6. It gives a hyacinthine colour to glass, which should be blue whilst it contained some mixture of cobalt.

7. The fusibility of the common regulus is nearly the same as that of copper.

8. But the purest regulus is much more difficultly melted, or calcined.

9. It calcines more difficultly than cobalt; and,

10. Its

lutions of a deep green colour. Its vitriol is of the same colour; but the colcothar of this vitriol, as well as the precipitates from the solutions, become by calcination of a light green colour.

8. These precipitates are dissolved by the spirit of sal ammoniac, and the solution has a blue colour; but being evaporated, and the sediment reduced, there is no copper, but a nickel regulus is produced.

9. It has a strong attraction to sulphur; so that when its calx is mixed with it, and put on a scorifying test under the muffel, it forms a compound with the sulphur which resembles the yellow steel-grained copper-ores, and is hard and shining on its convex surface.

10. It unites with all the metals, except quicksilver and silver. When the nickel regulus is melted with the latter, it only adheres to it, both the metals lying near one another on the same plane; but they

10. Its calx, which is *green*, rises in a tuberose fungous form; but if nickel is thoroughly purified from arsenic, its calces are of a brown colour.

11. It is difficultly soluble in the *vitriolic* or *marine* acid, but easily in the *nitrous*.

12. All these solutions, which are green, turn to blue by the addition of volatil alkali; but iron discovers no copper in them, as it does in every combination of *copper*, *sulphur*, *iron*, *arsenic* and *cobalt*.

13. Hence nickel must be deemed a distinct semi-metal. Besides, Bergman has shewn that *sulphur*, *arsenic*, and *cobalt*, may be perfectly separated from nickel, though perhaps *iron* cannot without the utmost difficulty.

they are eafily feparated with a hammer.

11. Cobalt has the ftrongeft attraction to nickel, after that to iron, and then to arfenic. The two former cannot be feparated from one another but by their fcorification, which is eafily done, fince

12. This femi-metal retains its phlogifton a long time in the fire, and its calx is reduced by the help of a very fmall portion of inflammable matter: it requires, however, a red heat before it can be brought into fufion, and melts a little fooner, or almoft as foon as copper or gold, confequently fooner than iron.

SECT. 390. (Additional.)

Native Nickel.

This is mentioned by Mr. *Rinman* to have been lately found in a mine of cobalt in *Heffe*;

It is very heavy, and of a liver colour, that is, dark red;

When pulverized and roafted under a muffle, it forms green excrefcences; and fmokes, but

14. It is, however, very evident, that if nickel has itfelf the property of being *magnetic*, as it was afferted N° 5, the teft of the load-ftone will always indicate, as if it contained a mixture of iron.

It is very probable, therefore, that nickel itfelf may be *magnetic*; and this feems to be the real cafe, as the more it is purified from iron, it becomes *more*, inftead of *lefs* magnetic; and even acquires, what iron does not, the properties of a true magnet. *The Editor from* Bergman *and* Kirwan.

its

its ſmoke has no particular ſmell: and no ſublimate, whether ſulphureous or arſenical, can be caught;

It is ſoluble in acids,

And the ſolution is green;

But a poliſhed iron plate diſcovers no copper.

SECT. 391. (255.)

Aerated Nickel.

The nickel is found.

A. In form of a calx, *Niccolum calciforme.* Nickel ochre, *Ochra niccoli.*

1. Mixed with the calx of iron, *Ochra niccoli martialis.*

This is green, and is found in form of flowers on Kupfernickel. In Normarken in the province of Wermeland, this ochre was found without any viſible nickel mixed in the clay, which contained a great quantity of native ſilver. *Sect.* 266, *p.* 542.

SECT. 392. (256.)

Kupfer nickel [*b*].

B. Mineraliſed nickel. *Niccolum mineraliſatum.*

1. With

[*b*] This ore is of a reddiſh-yellow, bright colour. Its texture is either uniform, granular, or ſcaly. It is bright in its fracture.

Is

1. With sulphurated and arsenicated iron and cobalt, *Niccolum ferro & cobalto arsenicatis et sulphuratis mineralisatum. Cuprum nicolai seu niccoli. Kupfernickel* [c].

This is of a reddish yellow colour, and is found,

a. Of a flaggy texture, in Saxony.

b. Fine-grained, and

c. Scaly, in Loos cobalt mines in the province of Helsingeland; at which place it is of a lighter colour than the foreign ones. These two are often, from their colour, confounded with the liver-coloured marcasite. Sect. 153.

SECT. 393. (257.)

Vitriolated Nickel.

2. With the acid of vitriol, *Niccolum acido vitrioli mineralisatum.*

This is of a beautiful green colour, and may be extracted out of the nickel ochre, (Sect. 391.) or efflorescence of the Kupfer-nickel. *See Sect.* 211.

Is very heavy; and

Is generally covered with a greenish efflorescence.

By calcination it loses much of its sulphur, and becomes green, forming fungous ramifications. *The Editor from* Kirw.

[c] Mr. Raspe assured me, that to his certain knowledge, nickel was found mineralized with sulphurated iron and copper, in a mine near Nelston, in Cornwall. *The Editor.*

SECT.

SECT. 394. (258.)

Observations on Nickel [d].

The cobalt, bismuth, and nickel, are commonly found together in the same mines, from which circumstance it happens, that, when the first, as the most useful of them all, is to be made into glass, the adherent nickel, according to its nature, unites with the sulphur and arsenic, of which some portion remains after the calcination, and forms a compound with them. When these minerals (the sulphur and arsenic) are in greater quantity than is wanted for the nickel, they likewise reduce some part of the calces of the cobalt and bismuth; and in this case the nickel, as a medium, uniting the other two, otherwise not miscible semi-metals, incorporates them into the same compound. From hence arises a difference in the contents of these different mixtures; and from this difference, people, who have not sufficient experience, form to themselves

[d] The ore of nickel must be subjected to roasting, in order to obtain its regulus: and, during this operation, a great quantity of sulphur and arsenic, greater or less, according to the quality of the ore, is expelled; so that it sometimes loses upwards of half its weight, but frequently not above 0,3. This ore, though long and compleatly calcined, does not always acquire the same colour: but in general becomes *greener*, in proportion as it is more rich. Sometimes, especially if suffered to lie at rest, its upper surface

selves false notions of the whole compound, and of each part contained in it. For which reason they chuse rather to retain that definition of the Kupfernickel which has received its sanction from the earliest authors, than to admit the conclusion to which Mr. Cronstedt's experiments seem to lead.

For my own part, I have found myself obliged to follow the opinion of the latter, partly because I am tired with those common epithets given to unknown bodies; such as, *wild*, *refractory*, *rapacious*, *arsenical*, *irreducible*, *metallic earth*, &c. which regard the effect alone and not its cause; and partly because I have not, besides the nickel, found any metal or metallic composition, which

1. Becomes green when calcined,

2. Yields a vitriol, whose colcothar also becomes green in the fire.

3. So easily unites with sulphur, and forms with it a compound of such a peculiar nature, as the nickel does in this circumstance; and that

4. Does

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face is covered with green vegetations, somewhat of the form of thin corals, which are hard and sonorous.

Let a double or triple quantity of *black flux* be added to the roasted powder, and the mixture well fused in a forge, in an open crucible, covered with common salt, according to the usual method. The vessel being broken, a metallic globule is found at the bottom, under the scoriæ, which are *brown* or *black*, or sometimes even *blue*. The weight of the globule amounts to 0,1, or 0,2; or, at most, to 0,5 of the crude ore.

This, however, is far from being pure; for although the roasting be ever so violent and long continued, yet a considerable quantity of *sulphur*, and especially *arsenic*, still remain concealed

4. Does not unite with ſilver, but only adheres or ſticks cloſe to it, when they have been melted together.

The nickel not having yet been found free from cobalt and iron, is the reaſon why it was not diſcovered. This was the caſe alſo with the cobalt. Platina del pinto perhaps, in the ſame manner, might for a long time have been mixed in the gold, at certain places, where it is ſaid to be naturally paler than any where elſe in the world. But the exiſtence of ſuch things cannot any longer be denied, ſince the method is diſcovered to obtain them ſeparate, and free from heterogeneous ſubſtances. It would be the ſame thing indeed, as if in a country where ſilver is never found but in the potter's lead ore, any perſon ſhould deny

cealed in the regulus, excluſive of the *cobalt* and a great proportion of *iron*, which laſt is generally ſo prevalent as to make the regulus *magnetic*, unleſs this ſemi-metal itſelf poſſeſſes this laſt quality; for it ſeems ſtronger in proportion as the regulus undergoes other further purifications.

Nine ounces of the ſame regulus of nickel, that had been eliquated by Mr. Cronſtedt, and kept in the Suabian collection of the Upſal Academy, whoſe ſpecific gravity was =7,410, were reduced to powder, and expoſed in ſeveral diſhes, for the ſpace of 6 hours, to an exceedingly vehement heat, under the dome of an aſſay furnace. By this the arſenic was firſt diſſipated with a fœtid ſmell: a ſulphureous odour was next perceived: afterwards a quantity of white ſmoke, was emitted without garlick ſmell, which probably aroſe from the ſublimation of the more dephlogiſticated arſenic: the ſurface ſwelled in heaps, and green vegetations ſprang out from all the ſurface, reſembling *moſs*, or the *fili-form lichen*. There remained at the bottom a powder of a ferrugineous aſh-colour, and 0,13 of the ſubſtance was diſſipated by this operation.

Half

deny the existence of either of these metals, or insist upon it, that one is produced from the other.

It is remarkable, that the precipitates of nickel give a blue colour to the spirit of sal ammoniac, when they are dissolved in it; without shewing any other marks of copper, which, however, could not be concealed, if there were any; for if a small quantity of copper is melted with the nickel, and kept in a strong fire with it, the copper soon separates, and scorifies, tinging the glass first of a reddish brown opaque, and, the fire being further forced, it then makes it transparent and green as usual.

There is no danger attending the encreasing the number of the metals. Astrological influences

Half an ounce of this powder or calx, being fused in a forge for 4 minutes together, with 3 times its weight of black-flux, yielded a regulus, the surface of which was reticulated, all the areolæ being hexangular, with exceeding slender striæ, diverging from a tuberculated center; its weight was = 0,73 of half an ounce; was obedient to the magnet; and when scorified with borax, left a blackish glass.

The roasting was repeated six times, for many hours: and the arsenic was separated by the addition of powdered charcoal; and the reduction being effected with equal parts of *white flux*, *lime*, and *borax*, a regulus was obtained, semi ductile, highly magnetic, and soluble in nitrous acid, which became of a green colour by the solution.

The regulus of nickel being mineralised a third time with sulphur, and reduced by powder of charcoal, produced a regulus, whose specific gravity was = 8,666; it not only adhered strongly to the magnet, but to any other piece of iron; nay, the small pieces of it attracted one another, and it was so ductile, fluences are now in no repute among the learned, and we have already more metals than planets within our solar system. It would perhaps be more useful to discover more of these metals, than idly to lose our time in repeating the numberless experiments which have been made, in order to discover the constituent parts of the metals already known. In this persuasion, I have avoided mentioning any hypotheses about the principles of the metals, the processes of mercurification, and other things of the like nature, with which, to tell the truth, I have never troubled myself.

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tile, that a globule, whose diameter did not exceed *one line*, was reduced by hammering to a plate of upwards of 3 lines in diameter: it was of a *whitish colour*, mixed with a glittering kind of *red*. The scoria of this regulus were almost always of a *hyacinthine colour*.

The analysis of nickel in the *moist way*, is as yet very imperfect. By solution in the nitrous acid it is freed from its sulphur; and, by adding water to the solution, bismuth, if any, may be precipitated, as may silver if contained in it by the marine acid.

To separate cobalt from nickel, when the cobalt is in considerable quantity, a saturated solution of the roasted ore of nickel is to be dropped into a liquid volatil alkali. The cobaltic part is instantly re-dissolved, and assumes a garnet colour. When filtered, a grey powder remains on the filter, which is the nickel. The cobaltic part may be precipitated from the volatil alkali by any acid.

If the ore be fused with 3 times its weight of *liver of sulphur*, the cobalt will be taken up, and may be separated by lixiviation.

It is highly probable that nickel exists in some species of roof-slates, and in horn-stones, whose solution in spirit of nitre is of a *green* colour. *The Editor from* Kirwan *and* Bergman.

N. B.

1. Manganese consists of a substance, which gives a colour both to glasses, and to the solutions of salts, or, which is the same thing, both to dry and to liquid menstrua; viz.

a. Borax, which has dissolved manganese in the fire, becomes transparent, of a reddish brown, or hyacinth colour.

b. The microcosmic salt becomes transparent with it, of a crimson colour, and moulders in the air.

c. With the fixed alcali, in compositions of glass, it becomes violet; but if a great quantity of manganese is added, the glass is in thick lumps, and looks black.

d. When scorified with lead, the glass obtains a reddish-brown colour.

e. The lixivium of deflagrated manganese is of a deep red colour.

2. It

---

the empty space with powdered charcoal, covering the crucible with another inverted and luted on, and exposing it to the strongest heat of a forge for one hour or more.

A small piece of the regulus, put into a dry bottle well corked, remained perfect for the space of 6 months; but afterwards exposed to the open air of a chamber for two days, it contracted a brownness on the surface, and became so friable, as to crumble between the fingers. The internal parts, however, retained an obscure metallic splendor, which disappeared in a few hours.

It melts readily with other metals, pure mercury only excepted. Copper united with a certain quantity of it, is extremely malleable; but upon the surface of this mixture, when polished, scarce any traces of the red colour are to be seen. This mixture sometimes, by age, produces a green efflorescence.

When

in order to diſtinguiſh them from the *Magneſia alba officinalis*, and in French *Manganeſe*, &c. They are by ſome lithographiſts entirely omitted, and by others ranked among the iron ores; but, as I am convinced both by my own experience, and by that of others, that they contain no greater quantity of metal than ſometimes two or three per cent. of iron, and ſometimes a little tin, I think that the remaining part, which muſt conſequently be conſidered as a kind of earth, deſerves a particular and ſeparate place in a Mineral Syſtem, at leaſt until a farther acquaintance with its nature may be obtained: and to this opinion I have been perſuaded by its following peculiar qualities:

1. Man-

This regulus is of a duſky white colour, with an uneven and irregular ſurface, ariſing from its imperfect fuſion. It is bright and ſhining in its fracture, but ſoon tarniſhes by expoſure to air; q. is harder than iron, leſs fuſible, and very little. Its ſpecific gravity is = 6,850

When pulveriſed it is always magnetic, though large pieces are not ſo. If expoſed to the air, particularly in moiſt weather, it ſoon crumbles into a blackiſh-brown powder, which is ſomething heavier than the regulus.

It is ſoluble in acids, but moſt readily in the nitrous. Its ſolutions are moſtly colourleſs; but that in the nitrous acid is generally browniſh, from a ſlight taint of iron: and there is always a ſpungy reſiduum of the nature of plumbago, left undiſſolved. Theſe ſolutions afford a white precipitate with aerated acids, which precipitate when heated, and grow black.

This regulus is obtained by mixing the calx, or ore of mangaⁿeſe, with pitch, making it into a ball, and putting it into a crucible with powdered charcoal $\frac{1}{10}$ of an inch thick on the ſides, and $\frac{1}{4}$ of an inch at the bottom. Then filling

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the empty space with powdered charcoal, covering the crucible with another inverted and luted on, and exposing it to the strongest heat of a forge for one hour or more.

A small piece of the regulus, put into a dry bottle well corked, remained perfect for the space of 6 months; but afterwards exposed to the open air of a chamber for two days, it contracted a brownness on the surface, and became so friable, as to crumble between the fingers. The internal parts, however, retained an obscure metallic splendor, which disappeared in a few hours.

It melts readily with other metals, pure mercury only excepted. Copper united with a certain quantity of it, is extremely malleable; but upon the surface of this mixture, when polished, scarce any traces of the red colour are to be seen. This mixture sometimes, by age, produces a green efflorescence.

When

2. It deflagrates with nitre, which is a proof that it contains some phlogiston.
3. When reckoned to be light, it weighs as much as an iron ore of the same texture.
4. When melted together with vitreous compositions, it ferments during the solution: but it ferments in a still greater degree, when it is melted with the microcosmic salt.
5. It does not excite any effervescence with the nitrous acid: aqua regia, however, extracts the colour out of the black manganese, and dissolves likewise a great portion of it, which, by means of an alcali, is precipitated to a white powder.
6. Such colours as are communicated to glasses by manganese, are easily destroyed by the calx of arsenic or tin: they also vanish of themselves in the fire.
7. It is commonly of a loose texture, so as to colour the fingers like soot, tho' it is of a metallic appearance when broken.

SECT.

When Manganese is melted with salt-petre, the mass, according to Dr. Brunnich, assumes a *green colour*.

Tin very easily unites with manganese; but zinc not without much difficulty, perhaps on account of its volatility and inflammable nature. White Arsenic adheres to it, and by means of phlogiston reduces it to a metallic form.

A mixture of powdered manganese with marine acid, is capable of dissolving gold, if thin plates of it be dipped in the mixture.

SECT. 396. (Additional.)

Native Manganese. Manganesium Nativum.

The discovery of native regulus of manganese, was far from being expected by rational mineralogists; for, as Mr. Kirwan observes, of all the metallic substances, manganese is the more ready to lose the proportion of the required phlogiston, for its natural mineralisation: and unless alloyed in native iron, there could be no hopes of seeing such a natural production.

We find, however, an account of this discovery, given by Mr. de la Peyrouse, in the *Journal de Physique*, for January 1786: by which

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Manganese, calcined by fire, yields a blackish calx; but if the ignition be continued for 12 days, it acquires a dark-green colour: sometimes also, it produces a white or a red calx. The black calx retains a very small portion of phlogiston, but the white abounds with it so much, that it is soluble in acids.

All these various calces, in a common crucible, by means of a sufficient degree of fire, run into a yellowish red glass, which is pellucid, unless too great a degree of thickness renders it impervious to the rays of light.

The black calx of this semi-metal, when mixed with other substances, attracts phlogiston with peculiar energy, and exhibits several remarkable phænomena both by fire and solution: which may be seen in the Treatise of Bergman upon the *White Grey calx of Iron.* The Editor from the same *Author*, and from *Kirwan.*

4

which it is evident that the manganesium does naturally exist in the bowels of the earth. The following are its remarkable properties.

1. Its external appearance, colour, and figure are the very same as those of the artificial regulus of manganese.
2. It likewise soils the fingers when handled.
3. Its substance is quite pure, having no particles that are in the least attracted by the magnet.
4. Its texture is lamellated, and the lamellæ seem to affect a kind of divergence among themselves.
5. It has the very same metallic brilliancy, as the artificial manganesium.
6. It has also a partial malleability: and, when repeatedly hammered,
7. It exhibits a kind of exfoliation, forming itself into very thin leaves.
8. Its opacity and density is so compleatly similar to that of the artificial regulus, that was it not for the natural matrix in which it is imbedded, it could not be at all distinguished from it.
9. This ore is not found in large masses, or in a solid continued body, but only in lumps, and unconnected clots, inclosed and intermixed with the powdery manganese ore.
10. These lumps are somewhat flattened, or compressed in their figure, like the artificial ones, though they are of a larger size for the most part.
11. And this powdery manganesian ore, in which the reguline lumps are inbedded, has an ar-

gentine hue, which feems to countenance the fufpicion of its having been acted upon, by the violent heat of fome natural deflagration on the fpot.

This new manganefe ore was found among the iron mines of *Sem*, on the valley called *Viederfos*, in the county of *Foix*, near the Pyrenean mountains.

SECT. 397. (114.)

Native Calces of Manganefe.

Manganefe is found [*b*],

A. Loofe and friable, *Manganefium friabile terreum.*

a. Black, feems to be weathered or decayed particles of the indurated kind, from England.

SECT.

[*b*] The aerial acid is the only mineralizer of Manganefe in its dry ftate; and, according to the different degrees of the phlogiftication of this femi-metal, it forms calces of different colours and different properties. It is to be underftood, that when manganefe is as much phlogifticated as it can be, without being in a reguline ftate, it forms a *white* calx, which contains a large portion of *fixed air* (about 40 *per cent.*) which enables it to retain phlogifton, becaufe the compound of acid and calx, attracts phlogifton more ftrongly, than either does fingly. In proportion, therefore, to its dephlogiftication,

SECT. 398. (115.)

White and Red Manganese.

B. Indurated, *Manganesia indurata.*
1. Pure, in form of balls, whose texture consists of concentric fibres, *Manganesia pura sphærica radiis concentratis.*
a. White [c], *Manganesia alba strictè sic dicta,* is very scarce. I have seen a specimen of this

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gistication, and its union with other substances, its colour is either *blue*, *green*, *yellow*, *red*, *brown*, or *black.*

The *blue* is that which it acquires from the proportion of phlogiston it is enabled to retain, by reason of its union with fixed alkalies. The *green* arises from a mixture of the *blue*, with the *yellow* calx of iron. *Yellow* always arises from the prevalence of the calx of iron. *Red* from a slight phlogistication of that calx; and *black*, from its thorough dephlogistication.

Yet, if the *black* calx be long roasted, it becomes *green*, which is thought to arise from the expulsion of the *fixed air*, which leaves its phlogiston with the manganese, and thus produces a *blue*, which, mixed with the *yellow* calx of iron, becomes of a *green* colour. The *brown* arises from a mixture of the *red* and *black* calces. All this note was extracted from *Scheele's Dissertation* on the subject, by *Kirwan.*

[c] This contains but a very small proportion of iron. It was found by Mr. Rinman both in small white crystals, and in round masses, on the cavities of quartz, and adhering to glanz-blend. It is rather less hard than lime stone.

It is of a sparry texture, and
Scarcely magnetic, even after roasting.
Is soluble with efflorescence in *nitrous acid*; and

this kind in a collection from an unknown place in Norway; and by examining a piece of it, I found that it differed from the common manganese, by giving to borax a deep red colour in the fire: this sort acquires a reddish brown colour when it is calcined.

b. Red manganese [*d*] is said to be found in Piedmont. This I have never seen; but

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Affords a colourless solution, from which with mild alkalis separates a white precipitate; and this, when heated, presently grows black; a sure criterion of being a true manganese.

Mr. Lapeirouse found this white ore in the form of a spongy efflorescence, vegetating on the surface of some iron-ores, particularly on *hæmatites*.

Mr. Rinman found it also in the form of calcareous spar, *of the colour of rosin*, and somewhat shining, covered over, in some places, with a sooty powder; and in thin pieces transparent at the edges, but not hard enough to strike fire.

Nitrous acid dissolves it almost entirely; with mild alkalis the solution affords a white precipitate, which becomes black when heated.

It consists of *manganese* bedded in zeolite. It melts *per se* with the blow pipe into a whitish grey porous slag; and, with the addition of calcined borax, gives a garnet colour to glass.

Many of the white sparry iron ores may also be classed among the ores of manganese, as they contain more of it than of iron. *Kirwan*.

[*d*] Red manganese contain less *fixed air*, and is accompanied with more iron than the preceding ore: and also with calcareous or ponderous earth; or barytes, and silex.

It is found either loose and semi-indurated in a matrix of calcareous spar; or on talky shistus; or on hæmatites, and other iron ores; or in heavy hard masses of lamellar, radiated, or equable texture; or crystallized in pyramids, rhomboids, or short brittle needles. *The Editor from* Kirwan. *See the note* [*e*] *to the next Section*.

I have

I have been told by an ingenious gentleman, that this variety is free from iron, and gives rather a red than a violet colour to glafs.

S E C T. 399. (116.)

Black Mangane∫e.

2. Mixed with a ∫mall quantity of iron, *Mangane∫ia parum martialis.*

a. Black mangane∫e, with a metallic brightne∫s. This is the mo∫t common kind, and is employed at the gla∫s-hou∫es, and by the potters [*e*].

It

[*e*] 1. There are ∫everal varieties of this ∫tone in the mountains round Bath, called *Mendip-hills*, of which the Bri∫tol potters con∫ume great quantities. *Brunnich.*

2. The *black* ore of Mangane∫e differs but little from the *brown* ones; and they are both found either cry∫tallized in the ∫ame form as the *red-ores*, or in ∫olid ma∫∫es, ∫ome of which have a metallic appearance; others are dull, earthy, and mixed, or embodied in quartz, or in a loo∫e earthy form.

3. Their ∫pecific gravity is about = 4,000.

Both, particularly the *brown* and the *red*, are ∫oluble in ∫ome mea∫ure by dige∫tion in *oil of vitriol:* the ∫olution is at fir∫t reddi∫h, but afterwards becomes colourle∫s, unle∫s they contain a large proportion of iron.

4. But neither the *Dephlogi∫ticated nitrous acid*, nor the concentrated *vitriolic acid*, act upon them, unle∫s *∫ugar*, *honey*, *gum*, or other ∫imilar *∫ub∫tance* be added; for then the ∫olution will be promoted and compleated. This proceeds, as Bergman remarks, from the exhau∫ted ∫tate of the calx,

It is found,

1. Solid, of a flaggy texture, *Manganesia textura vitrea*, from Skidberget, in the parish of Leksand, in the province of Dalarne.

2. Steel

calx, which has not phlogiston enough to be acted upon by the acid, unless these substances furnish the calx therewith.

5. If this calx is boiled with a solution of sugar in water, it is not supplied with phlogiston; and on being separated by lotion, remains insoluble as before. But if an acid be also added, by the help of it, a translation of the phlogiston then takes place, and the calx by its means takes up as much phlogiston as to be rendered soluble; nay, the phlogisticated vitriolic acid, when poured upon this calx, soon loses its smell, and dissolves it readily without any assistance.

6. The solution, just now mentioned, either by the dephlogisticated nitrous, or by the concentrated vitriolic acid, is colourless; and, with mild alkalis, affords a white precipitate of the same nature as that already mentioned, Nº 3.

7. These calces, the *black* and *brown*, contain more iron and less fixed air, than the *red* and *white* ones, already spoken of.

The Perigord stone, Lapis Petracorius.

8. To the last variety of black manganese belongs the true *Perigord stone*; which is of a dark grey colour, like the *basaltes* or *trapp*. It may be scraped with a knife, but it is difficultly broken. Its structure is amorphous, very compact, heavy, and as black as charcoal. It has a glittering appearance of a striated kind, like the antimonial ore: and its particles are disposed in the form of needles, crossing one another without any aglutination, insomuch that some are loose in the same manner as iron filings when stuck to a loadstone; upon the whole they resemble the scoria from a black smith's furnace.

9. This substance, when calcined, becomes of a reddish brown colour, and harder; but is not magnetic. Its specific gravity

2. Steel grained, alſo from Skidberget.
3. Radiated, *Radiata*, alſo from Skidberget, and Tiveden, in the province of Oſtergottland.
4. Criſtalliſed.

a. In

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gravity is conſiderable. It does not melt *per ſe*; but with borax it affords an amethyſt-coloured glaſs. Nitrous acid ſcarcely acts on it, without the addition of ſugar. This ſtone ſeems alſo to contain argill, and ſome portion of iron.

10. It is found in Gaſcony and Dauphiny, provinces of France, and in ſome parts of England. The French potters and common enamelers employ this ſubſtance ſometimes in the glaſſy varniſh of their earthen wares, &c. *The Editor from* Kirwan *and* Bomare.

Blackwadd.

11. This ſubſtance is found in Derbyſhire, and is one of the moſt remarkable ores of manganeſe. It is of a dark brown colour, partly in powder, and partly indurated and brittle. If half a pound of it be dried before a fire, and afterwards ſuffered to cool for about one hour, and then 2 ounces of linſeed oil be gradually poured on it, mixing the whole looſely like barm with flour, little clots will be formed: and in ſomething more than half an hour, the whole will grow hot, and at laſt burſt into a flame. The temperature of the room where this experiment was repeated, was about 30 *deg.* of Fahrenheit; and the heat this ore was expoſed to while drying, might be about 130 *degr.*

12. According to Wedgwood's analyſis, 100 parts of *blackwad* contain 43 of manganeſe, as much of iron, 4,5 of lead, and near 5 of micaceous earth. *The Editor from* Kirwan.

Manganeſe in vegetables.

13. Manganeſe ſeems to be contained in the aſhes of moſt vegetables; and to it the blue and greeniſh colour of calcined vegetable alkali is owing. Theſe colours are generally attributed to the phlogiſton of the alkali; but if ſo, they ſhould

not

a. In form of coherent hemispheres, *Hemispheriis continuis*, from Skidberget in Leksand.

SECT. 400. (118.)

OBSERVATIONS on MANGANESE (*f*).

Though it may seem difficult to many, to distinguish the kinds of manganese by their appearance,

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not be found in fixed nitre, as the nitrous acid should carry off, during its decomposition, all the phlogiston. Yet this alkali is always greenish, so that the colour seems to arise from the ashes of the charcoal with which the nitre was decomposed.

If 3 parts of the alkali of tartar, 1 of sifted ashes, and $\frac{1}{8}$ of nitre, be melted together, they form a dark green mass, which being dissolved in water, affords a beautiful green solution; and this being filtered, on the addition of a few drops of oil of vitriol, becomes *red*; and after a few days a brown powder is deposited, which has the properties of manganese. The ashes of serpyllum contain very little of it. Those of trees contain most. *The Editor chiefly from* Bergman *and* Kirwan.

[*f*] For reducing almost all the metallic-ores, some kind of fluxes are to be employed according to their kinds and circumstances: but manganese has no need of any flux at all, requiring only to be exposed to a quick and very violent heat at once; and such is its propensity towards vitrification, that the regulus never can be reduced to a single mass, but it is generally formed into various small lumps, dispersed between the remaining calces, as Mr. de la Peyrouse observes.

To analyse the above-mentioned ores of manganese, they should be first roasted, to dephlogisticate the calx of the semi-metal, and the iron, if any is there contained. They are appearance, or external marks; yet it is extremely eafy to know them by experiments made in the fire, if attention is had to the above-mentioned phænomena (Sect. 395.). From hence it is not difficult to comprehend why manganefe has hitherto been either omitted, or erroneoufly ranked in fyftems, viz. becaufe it has, like many other mineral bodies, been examined only by fight, while the more troublefome method of examining it in the fire, has been overlooked.

Some might perhaps imagine the manganefe to be the refidue of fome metal, which cannot be reduced again into its metallic ftate; but it ought to be remembered, that no metal can, by any means yet known, be brought to an abfolutely irreducible earth or calx, unlefs perhaps by the burning-glafs: and therefore there is no reafon to fufpect that nature affords fuch a production. Ignorance and idlenefs have invented certain terms or expreffions, to avoid

are then to be treated with dephlogifticated nitrous acid, in order to diffolve the earths. The refiduum fhould then be treated with nitrous acid and fugar, by which means a colourlefs folution of manganefe will be obtained; which, being precipitated by aerated mineral alkali, will afford a precipitate, 100 *gr.* of which are equivalent to as many of the regulus of manganefe.

Many fpecies of iron contain alfo manganefe: and to difcover it, let the iron be diffolved in an acid, and precipitated by the Pruffian alkali; let the folution be poured off, and the precipitate digefted in pure water. The Pruffian manganefe will be diffolved, and the Pruffian iron will remain undiffolved.

Otherwife, if a fmall piece of the ore be heated white in a crucible, and 5 times its weight of purified nitre be projected on avoid giving an account of thofe ores or mineralifations, which are not eafy enough to be decompounded; for inftance, *wild*, *rapacious*, *arfenical*, *volatile*, &c. and fome iron ores in particular have been thus called; by which means it has happened, that œconomical reflections have often been added to natural and philofophical defcriptions: and thus others are deterred from examining many bodies, of which we have acquired, and ftill retain falfe notions arifing from this way of proceeding.

The manganefe has by fyftematifts been commonly ranked among fuch iron ores; but the artificers who make ufe of it in the manufacture of glafs do not look upon it as fuch; nor can they by any means be perfuaded to ufe any of the pretended bodies akin to it, inftead of the manganefe itfelf, for experience prevails more with them than fuppofitions. The confumption of manganefe is but fmall, and therefore it is not a very profitable article.

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on it, taking care that no coal or afhes fhould get into the crucible; when all is cold, the upper part of the crucible will be covered with a *greenifh* or *bluifh* cruft, if the iron contains manganefe. When the folution of the iron, in the marine acid, is of a *red* colour; this alfo denotes the prefence of manganefe, though this colour foon changes to a *yellow*, by acquiring phlogifton from the martial part.

Manganefe is of great ufe in the manufactory of glafs and cryftal, to deprive them of their green colour, which they would otherwife retain. Potters alfo make a great ufe of it for the glafs-varnifh of their earthen and porcelain ware. But modern chemifts employ it for other interefting purpofes, fuch as to dephlogifticate various menftrua for delicate proceffes, &c. *The Editor from* Bergman *and* Kirwan.

SECT.

S E C T. 401. (*part of* Sect. 154.)

Molybdena. *Molybdena*, Lat. *Blyertz. Wasserbleij*, Sw. *Wasserbley. Reisserbley*, Germ. *Molybdena*, French.

a. Lamellar and shining, of the same colour as the potters lead ore. *Molybdæna pura membranacea nitens* [a].

From

[a] This substance resembles the plumbago of Sect. 231, and has long been confounded with it, even by our Author; but,

1. Its laminæ are larger, brighter: and, when thin, slightly flexible. They are of an hexagonal figure.

2. It is of a lead colour, and does not strike fire with hard steel.

Its specific gravity is=4,569, according to Kirwan; and 4,7385, according to Brisson.

4. When rubbed on white paper, it leaves traces of a dark brown or bluish colour, as the plumbago or black lead does; but they are rather of an argentine gloss, by which circumstance the Molybdena, according to Dr. d'Arcet, may be easily distinguished from black lead, as the traces made by this last are of a darker hue, less brilliant, and of a deeper tinge.

5. In an open fire it is almost intirely volatil, and infusible. Microcosmic salt, or borax, scarcely affect it; but it is acted upon with much effervescence, by mineral alkali, and forms with it a reddish mass, which smells of sulphur.

6. It is affected by no acid but the nitrous and arsenical, both of which require the assistance of heat; the latter is converted into orpiment by it.

7. It consists of an acid of peculiar nature (described in Sect. 162), united to sulphur. A small proportion of iron is commonly found in it, but this seems merely fortuitous:

From Bifpergs Klack in the province of Dalarne, Baftnas-grufva at Riddarfhyttan in Weftmanland, Altenburgh in Saxony.

The variety from Bifpergs Klack has been examined by Mr. Quift, and has, by its volatilifing under the muffel, in form of a white fibrous

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100 parts of molybdena contain about 45 of this acid, and 55 of fulphur.

8. It is decompofed either by detonation with nitre, or by folution in nitrous acid; the latter method is the readieft. For this purpofe it is to be five times diftilled, each time with four times its weight of fpirit of nitre: a white calx at laft remains, which is the molybdenous acid.

9. This acid is foluble in 570 times its weight of water in the temperatnre of 60; the folution reddens that of litmus, precipitates fulphur from the folution of liver of fulphur, &c. The fpecific gravity of the dry acid is 3,460. 3 *Bergm.* p. 127.

10. This acid is precipitable from its folution in water by the *Pruffian* alkali, and alfo by tincture of galls: the precipitate is reddifh brown.

11. If this acid be diftilled with three times its weight of fulphur, it re-produces molybdena.

12. The folution of this acid in water unites to fixed alkalis, and forms cryftallizable falts; as it alfo does with calcareous earth, magnefia, and argil; thefe laft combinations are difficultly foluble; it acts alfo on the bafe metals, and with them affumes a bluifh colour.

13. This folution precipitates filver, mercury, or lead, from the nitrous acid, and lead from the marine, but not mercury.

24. It alfo precipitates barytes from the nitrous and marine acids, but no other earth. Molybdenous barofelenite is foluble in cold water.

15. This acid is itfelf foluble in the vitriolic acid by the affiftance of heat; and the folution is blue when cold, though colourlefs while hot; it is alfo foluble in the marine acid, but not in the nitrous.

16. Molybdenous

fibrous sublimate, induced that gentleman to examine the black lead more particularly. He has published some very remarkable experiments on it in the Transactions of the Academy of Sciences at Stockholm, for the year 1754.

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16. Molybdenous tartar and ammoniac precipitate all metals from their solutions by a double affinity. Gold, sublimate corrosive, zinc, and manganese, are precipitated *white*; iron, or tin, from the marine acid, *brown*; cobalt, *red*; copper, *blue*; alum and calcareous earth *white*. *Scheele Mem. Stock.* 1778.

17. This acid has been lately reduced by Mr. *Hielm*, but the properties of the regulus thus obtained are not yet published.

18. Mr. Pelletier obtained also the regulus of molybdena, by mixing its powder with oil into a paste, and exposing it with powdered charcoal in a crucible, to a very violent fire for two hours. By this process he obtained various globules or beads of regulus, which he found to have the following properties: 1. It may be deprived of its phlogiston by calcination, and reduced to a calx more or less white: 2. It detonates with nitre on the fire, and a combination of the calx with the alkali remains behind: 3. with nitrous acid, it becomes calcined into a white calx: 4. in the dry way treated with alkalis, it produces inflammable air: 5. it unites with metallic substances, forming as many alloys: 6. and treated with sulphur, regenerates mineralized molybdena.

19. This semi-metal being urged by a strong fire for an hour, produces a kind of silvery flowers, like those of Antimony,

20. It is said that molybdena is soluble in melted sulphur, which seems highly probable, as sulphur is one of its component parts.

Molybdena is found sometimes along with Tin ores, and Iron ores, that are attracted by the magnet, among copperish pyrites; and also with Wolfram, not only in Saxony, Iceland, France, but in Spain, Sweden, &c. *The Editor, from* Kirwan, Scheele, Pelletier, &c.

SECT. 402. (117.)

Wolfram. Wolfranum, Spuma Lupi, *Lat.*

This mineral has the appearance of Manganese, blended with a small quantity of iron and tin, *Manganesia, parvâ cum portione martis et jovis mixta: Spuma Lupi,* or *Wolfram* [b].

1. With

b. 1. This mineral, which the Germans have called *Wolfram*, or Wolfrath, a name translated into Latin *Spuma Lupi*, or rather *Lupus Jovis*, has been met with hitherto only in mines of tin; for, though many authors would make it more common, it is an error owing to their confounding some glossy iron-ores with the true Wolfram, as appears by the specimens which are frequently found in Cabinets under this name. It has been on account of the bad effects produced by this mineral in the smelting of tin-ores, from which it is very difficult to separate it by washing, because of its great specific weight, that the names of *Spuma Lupi*, *Lupus Jovis*, and *Wolfram*, have been given to it, by the miners and smelters.

2. This is really a metallic ore, and contains the very semi-metal lately discovered in the *Tungstein* of Sect. 27: both being mineralized, or rather formed by the same *Tungstenic* acid, already described in Sect. 163. And having treated already in these two Sections of both, it only remains now to speak of the *Wolfram*.

3. This metallic ore, which is generally found in tin mines, as before said, is of a black or brown shining colour, of a radiated or foliated texture, of a moderate hardness, and sometimes so brittle as to be easily broken between the fingers; but it is very weighty, since its specific gravity is = 7,119.

4. When

1. With coarse fibres.

a. Of an iron colour, from Altenberg in Saxony. This gives to the glass compositions,

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4. When scratched it shews a red trace, and this distinguishes it from the Tungstein of Sect. 27. which is a variety of the ore of the same semi-metal.

5. It is found in scattered masses, crystallized into hexaëdral flat prisms, coming to a point, with 4 sides, and these points terminated obliquely.

6. Internally it is shining, with the lustre almost of a metal.

7. When it is broken, its texture appears leafy; and the leaves are flat, but somewhat confused;

8. On some sides they are unequal, and very seldom striated.

9. It is always opake; and when scraped, it yields a powder of a dark reddish grey.

10. The Wolfram will not melt by itself with the blowpipe: the angles being only rounded; but

11. Internally it preserves its structure and colour without change.

12. With microscomic salt it fuses with effervescence; and forms a glass of a pale red in the exterior flame, and much darker in the interior.

13. With borax it likewise effervesces, and forms by the interior flame a glass of a greenish yellow, which by the exterior turns reddish.

14. Being exposed in a crucible to a strong fire for one hour, it swelled, became spongy, and of a brownish colour; entered into a semi-vitrification; and was attracted by the magnet.

15. Equal parts of nitre and wolfram being put in a red-hot crucible, they detonated, or rather boiled up with a blue flame round the edges; and a nitrous vapour arose: the matter, when cold, on being put into water, partly dissolved: and a few drops of acid produced a white precipitation.

16. Pounded Wolfram, digested in a sand-heat with a sufficient quantity of marine acid, to the depth of the thickness

tions, and also to borax and the microcosmic salt, an opaque whitish yellow colour, which at last vanishes.

On

of a finger above the matter, after one hour's boiling, the powder turned yellow; which is the same phenomenon as happens with the tungstenic acid of Sect. 163.

17. It appears by the chemical analysis of Wolfram made by Mess. John and Faust de Luyart, that its contents consist of 22 parts of manganese in the state of black calx; 13,5 of iron, 65 of a yellow wolfranic calx, and of quartz and tin.

18. A good quantity of this yellow calx being collected, it was observed that it was entirely insipid, and that its specific gravity was=6,120. It effervesces with microcosmic salt: produces a transparent blue colour without any shade of red; and effervesces also with borax, and with mineral alkali. This same matter does not dissolve in water; but when triturated with it, forms a kind of emulsion; to which the acetous acid gives a blue colour, but does not dissolve it. This matter, however, dissolves compleatly in caustic vegetable alkali, both by the *dry* and *moist way*; and the liquor acquires a great bitterness. By pouring on it some nitrous acid a precipitate ensues, which leaves on the filtre a white salt; and this being well edulcorated, has a taste at first *sweet*, afterwards *sharp* and *bitter*, producing a very disagreeable sensation on the throat. It is in fact a true acid combined with a portion of the alkali and precipitating acid.

19. This acid melts, if alone, by the flame urged with the blow-pipe.

20. This white salt is a true metallic triple salt, as appears by putting 100 *gr.* in a crucible with powdered charcoal; for after one hour and a half of a strong fire, when cooled a button was found, which fell to powder between the fingers. Its colour was brown; and, on examining it with a magnifier, there was a congeries of metallic globules, of the bigness of pin's heads; which, when broken, exhibit the metallic appearance, of a steel colour in the fracture: and their specific gravity was=17,600.

21. These

On the Siderite.

The supposed new metal, named Siderite, *was first discovered by Mr. Meyer of Stetin. But Professor Bergman and Mr. Kirwan (besides various other chymical and mineralogical philosophers) soon applied themselves to investigate the properties of this substance, till at last the same discoverer, Mr. Meyer, happily ascertained by the synthetic method, that it was nothing else but a natural combination of the phosphoric acid with iron; and published an account of his mistake. This very combination, however, is an important discovery in nature, and the knowledge acquired by the investigation of its properties, is a very valuable acquisition to the common stock of modern discoveries. The words of the same ingenious philosopher, the inventor, may*

21. These metallic globules, melted with other metals, gold and platina excepted, afford ductile alloys with silver or copper; and hard ones with cast iron, tin, antimony, bismuth, and manganese.

22. It is therefore evident that this is a new metal before unknown, as it is evinced, 1. by its specific gravity, equal to 17,600: 2. by the tinges it gives to different glasses: 3. by its great difficulty to fuse, which is greater than that of manganese: 4. by the yellow colour of its calx: 5. its alloys with other metals: 6. its insolubility, at least by a direct method, with mineral acids: 7. its easy solution in alkalis: 8. the emulsion it gives with water: 9. and by the blue colour it gives to acetous acid. All these properties are sufficient to demonstrate that this Wolfranic substance is a metal *sui generis*, distinct from all others. *The Editor, chiefly from the* Chemical analysis of *Wolfran*, by *Mess. de Luyart.*

serve to shew this: what a plentiful source, says he, of *phosphoric acid* would be opened to us, if it were but easy to separate! The close combination of this acid with iron, is also very remarkable.

Mr. Klaproth of Berlin, by a remarkable coincidence, came to the very same conclusion, without any communication with Mr. Mayer. He did not attempt to establish his opinion by analytical experiments, as he conceived that it would be difficult to separate the iron and the acid, either by phlogiston or any other way. He found, however, the artificial compound of phosphoric acid *and* iron, *to agree in its properties with the* calx sideri alba, *obtained by Bergman and Mayer from the* cold-short iron, *which is extracted from the* swampy *or* marshy *ores, described at p. 732. The* native Prussian blue iron ore, *of Sect. 341, which is extracted from similar ores, contains also the same combination of the siderite in a much larger portion.* The Editor from *Bergman,* and his *English Translator.*

On the Saturnite.

Mr. Kirwan gave this name to a supposed new metallic substance, announced by Mr. Monnet, as found in the lead-founderies of Poullaouen *in Brittany, where it is separated from the lead ore, during its torrefaction. It is described as resembling lead in its colour, specific gravity, solubility in acids, and other similar qualities to those of lead: excepting only that it is more*

fusible,

fusible, very brittle, easily scorified and volatilized; and not miscible with lead, when in fusion.

But Mess. Hassenfratz and Giroud have demonstrated, both by the analytical and synthetical methods, that this very metallic substance, the saturnite, *which was formerly neglected, but which is now kept for useful purposes at the said founderies of Poullaouen, is nothing but a simple mixture or alloy of various metals, which separates of itself, on account of its greater fusibility, whilst the lead-ores are roasting in the furnace.*

The following table is extracted from Journal de Physique, *for January* 1786, *p.* 63, *and shews the names and respective quantity of each metal that is generally combined in the* saturnite. *It is easily conceived, that they must often vary, according to the different ores that happen to be roasted at every time in the furnace.*

	lb.	oz.	gros.	grains.
Lead	40	13	6	6
Copper	31	4	0	0
Iron	4	1	2	0
Silver	0	2	1	66
Sulphur	23	10	6	0
The Sum	100	0	0	0

There will be no difficulty in reducing these French *weights into the* English, *by taking notice of the following circumstances:*

	grains.
1st, that the French pound, or livre *of two* marks, *contains*	9216

 and

and is divided into 16 *ounces, each containing* grains. 576
or into 128 *drams (or* gros*), each weighing* 72
2*dly, that the proportion of the* French *pound weight to the* English, *called* avoirdupoids, *is,* according to Paucton's Metrologie, as 10000 : 0,9264.
3*dly, that in consequence of this proportion, this last (the English pound,* averdupois) *is equal to* 8537, 7024 *French grains*
4*thly, But as the same English pound contains only* 7000 English grains; *it follows, that these English grains are greater than the French ones, in the proportion of* 85 (*or* 85,38) *to* 70; *so that* 85 *French grains are equal to* 70 *English ones.* The Editor.

It appears, however, by the *Journal de Physique* for March following, p. 169. that M. Monnet does not admit that the Saturnite, analysed by Mess. Hassenfratz and Giroud, is of the same kind as that discovered by him; and he adds, that on his having recourse again to the Mines of Poullaonen, in 1783, his new metal was not to be found. We can only add, that this is a most singular disappointment!

APPENDIX,

APPENDIX.

SECT. 403. (259.)

INTRODUCTION.

I Have already in the preface mentioned the reasons why the Saxa and Fossils commonly called *Petrefactions* cannot be ranked in a Mineral System: and I am persuaded, that the same reason which has prevailed on me, will likewise after mature consideration be approved by others. In the mean time, since these bodies, especially the latter, occupy so considerable a place in most Mineral Collections, and the former must necessarily be taken notice of, by the miners, in the observations they make in the subterranean geography, I would not entirely omit them here; but have endeavored to put them in such an order as may answer that purpose, for which Miners and Mineralogists pay any regard to them.

SECT. 404. (260.)

The FIRST ORDER.

SAXA. *PETRÆ.*

I divide these into two kinds.

1. Compound Saxa, *Saxa composita*,

Are stones whose particles, consisting of different substances, are so exactly fitted and joined together, that no empty space, or even cement, can be perceived between them; which seems to indicate, that some, if not all, of these substances have been soft at the instant of their union.

2. Conglutinated stones, *Saxa conglutinata*,

Are such stones whose particles have been united by some cementitious substance, which, however, is seldom perceivable, and which often has not been sufficient to fill every space between the particles. In this case the particles seem to have been hard, worn off, and in loose, single, unfigured pieces, before they were united.

SECT. 405. (261.)

1. Compound Saxa, *Saxa Composita*.

A. Ophites. Scaly limestone with kernels or bits of serpentine stone in it, *Saxum*

2 *compositum*

compositum particulis calcareis et argillaceis.

1. *Kolmord marble.* It is white and green.
2. *Serpentino antico,* is white, with round pieces of black steatites in it. This must not be confounded with the *Serpentino verde antico,* of Sect. 409.
3. The *Haraldsio marble.* White, with quadrangular pieces of black steatites.
4. The *Marmor Pozzevera di Genova.* Dark green marble, with white veins.

This kind receives its fine polish and appearance from the serpentine stone.

SECT. 406. (262.)

B. Stellsten or Gestellstein. *Saxum compositum particulis quartzosis & micaceis.* Granitello.

1. Of distinct particles, *Particulis distinctis.*

This is found at Garpenberg in the province of Dalarne. It is likewise met with in the other mineral mountains of Sweden. In some of these the quartzose particles predominate, and in others, the micaceous. In the last case it is commonly slaty, and easy to split.

2. Of particles which are wrapt up one in another, *Particulis quartzosis mica convolutis.*
   - *a.* Whitish grey, from Morthernberget in Norberke in Dalarne.
   - *b.* Greenish, at Salberg in Westmanland.
   - *c.* Reddish, from the parish of Malung in Dalarne.

Both

Both these kinds of Stellsten are, for their resistance to the fire, employed in building furnaces; but the latter is the best, because it seems at the same time to contain a little of a refractory clayish substance. The reddish from Malung however cracks very soon, if the flat side of the stratum, instead of the extremity, is turned towards the fire. It is also of great use in mills, if the other or fellow-stone is made of the mill-stone from Arsunde, which is a Saxum of the conglutinated kind, or a coarse sand-stone. It is fortunate for œconomical purposes, that the plates of these stones are so thick, although thereby they are not so easily split.

SECT. 407. (263.)

C. *Norrka* and *Murksten* of the Swedes, *Saxum Compositum, mica, quartzo, et granato.*

1. With distinct garnets or shirls, *granatis distinctis crystallisatis.*
   - *a.* Light grey, from Selbo in Norway.
   - *b.* Dark grey, with very small garnets, from Quarnberget in the parish of Soderli in the province of Jemteland.
   - *c.* Dark grey, with prismatical, radiated, or fibrous cockle or shirl, from the village of Handol, in the parish of Are in Jemteland.
2. With kernels of garnet stone, *Particulis granatis indeterminatis.*

a. Of pale red garnet ſtone, from Stollberget in Norberke in Dalarne.

The firſt of this kind, whoſe ſlaty ſtrata makes it commonly eaſy to be ſplit, is employed for mill-ſtones, which may without difficulty be accompliſhed, if ſand is firſt ground with them, becauſe the ſand wears away the micaceous particles at the ſurface, and leaves the garnets prominent, which renders the ſtone fitter for grinding the corn.

SECT. 408. (264.)

D. The Whetſtone, *Cos*. *Saxum compoſitum micâ, quartzo, et forſan argillâ martiali in nonnullis ſpeciebus.*

1. Of coarſe particles, *Particulis diſtinctis*.
   a. White, from Wanga in the province of Skone.
   b. Light grey, from Tellemarken in Norway.
2. Of fine particles, *Particulis minoribus*.
   a. Liver brown colour, from Selbo in Norway.
   b. Blackiſh grey, from Lerwik in Hellefors in Weſtmanland, and from Cologne in Germany.
   c. Light grey, from Hellefors in Weſtmanland.
   d. Black. The table ſlate, or that kind uſed for large tables, and for ſchool-ſlates.

The

The naked eye, and the magnifying glass much better, discovers the micaceous particles in this kind to be as it were twisted in one another. Some clay seems likewise to enter into the composition. However, it cannot yet be certainly asserted, that it is real mica which has that appearance in this kind.

3. Of very minute and closely combined particles, *Cos particulis constans impalpabilibus durus.* The Turky stone [a].

This is of an olive colour, and seems to be the finest mixture of the first species of this genus. It is found in loose stones at Biorkskoginas in the parish of Hellefors in Westmanland, though not perfectly free from cross veins of quartz, which always are in the surface of the rock, and spoil the whetstones. It is also said to be found in Tellemarken in Norway. The best sort of this comes from the Levant and is pretty dear. The whet-stone kinds, when they split easily, and in thin plates, are very fit to cover houses with, though most of them are not of such qualities.

N. B. *The Sect. 265. in which the Author described the* Telgstein, *has been placed among the* Magnesian earths, *in Sect. 61. p. 104. to which it properly belongs.* The Editor.

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[a] *See Sect. 126, where this stone is fully described.* The Editor.

SECT.

SECT. 409. (266.)

F. Pophyry, *Porphyrites.* Italorum *Porfido.* *Saxum compoſitum jaſpide et feltſpato, interdum micâ et baſalte* [*b*].

a. Its colour is green, with a light green feltſpar, *Serpentino verde antico.* It is ſaid to have been brought from Egypt to Rome, from which latter place the ſpecimens of it now come.

b. Deep red, with white feltſpar, from Italy, and Egern in Norway.

c. Black, with white and red feltſpar, from Klitten, in the pariſh of Elfdalen in Dalarne.

d. Reddiſh brown, with light-red and white feltſpar, from Hykieberget in Elfdalen, and Guſtavſtrom, in the pariſh of Goſborn in the province of Wermeland.

e. Dark grey, with white grains of feltſpar alſo from Gulavsſtrom.

Many varieties of this kind, in regard to colour, are found in form of nodules or looſe ſtones in Sweden; but I have only mentioned the hardeſt and fineſt of thoſe which are found in the rocks; becauſe, beſides theſe, there are coarſe porphyries found, which ſcarce admit of any poliſh. The dark red pophyry has been moſt employed for ornaments, in building, &c. yet it is not the only one known by the name of *Porfido*, the Italians applying the ſame name alſo to the black kind.

SECT.

[*b*] Under the name of *Porphyry*, or *Porfido* of the Italians, both Mr. de Sauſſure and Mr. Kirwan reckon thoſe ſtones, which contain either *feltſpar*, *quartz*, *ſhoerl*, *mica*, with other ſpecies of ſtone of a cryſtalline form, in a *ſiliceous*, or even *calcareous*

SECT. 410. (267.)

G. The *Trapp* of the Swedes. Saxum compositum jaspide martiali molli, seu argillâ martiali induratâ. . . . . [d].

This kind of stone sometimes constitutes or forms whole mountains; as, for example, the

calcareous ground. Mr. Ferber, in his 16th letter from Italy, describes 20 varieties of Porfido, under four species. But in general it is considered according to the colour of its ground, *viz.* either *red*, *purple*, *grey*, *green*, or *black*. When the ground is of jasper (Sect. 107. and following), the porfido is very hard. The *red* commonly contains *felt-spar*, in small white dots or specks, and often together with these, black spots of shoerl. The *green* is either a jasper or shoerl, with spots of quartz. This is often magnetic. Sometimes a porphyry of one colour contains a fragment of a porphyry of another colour. Those that have *chert* for their ground, are fusible *per se*. The Calcareous Porphyry consists of *quartz*, *felt-spar*, and *mica*, in separate grains, united by a calcareous cement. And finally, the Micaceous Porphyry, consists of a greenish-grey micaceous ground, in which red felt-spar and greenish soap-rock are inserted. *The Editor.*

[d] This stone is so called, on account of its most common external appearance or figure; it being formed into steps like a stair, called *trapp* in Swedish. Bergman found that this stone has the same component parts as the basaltes; and there cannot be the least doubt of both being the very same substance.

It is generally called *Saxum Danemorense*. According to Kirwan, it is composed of *Siliceous earth*, mixed with 0,3 of its weight of *argill*, 0,17 of *mild calcareous earth*, 0,04 of magnesia, and 0,5 of *iron*. Bergman, however, had expressed the same contents of this stone in an easier way, at p. 213 of his Treatise *de Productis Vulcanicis* of Upsal's edition, 1773; saying that the trapp has the very component parts, and in the same proportion, as the *basaltes*, viz. in 100 parts, 52 are of *siliceous* earth; 15 of *argillaceous*; 8 of *aerated* the mountain called Hunneberg, in the province of Westergottland, and at Drammen in Norway. But it is oftener found in the form of veins in mountains of another kind, running commonly in a serpentine manner, contrary or across to the direction of the rock itself. It is not homogeneous, as may be plainly seen at those places where it is not pressed close together; but when it is pressed close, it seems to be perfectly free from heterogeneous substances.

When this kind is very coarse, it is interspersed with feltspar; but it is not known if the finer sorts likewise contain any of it. Besides this, there are also some fibrous particles in it, and something that resembles a calcareous spar. This however does not ferment with acids; but melts as easily as the stone itself, which becomes a black solid glass in the fire. By calcination it becomes red, and yields in assays 12 or more per cent. of iron. No other sort of ore is to be found in it, unless now and then somewhat merely superficial lies in its fissures; for this stone is commonly, even to a great depth in the rock, cracked in acute angles, or in form of large rhomboidal dice. It

aerated calcareous; and 25 of *iron*, if analysed by the *phlogisticated* alkali; if otherwise, by the common method, only 10 parts of the iron could be determined.

But although this great man found the same component parts, and the very similar appearances, both in the basaltes and the trap, he did not admit the last to be a volcanic production. I leave to the reader to decide upon the arguments on which this great man has grounded his doubts: yet since small pieces of lavas, and other volcanic productions, are really

 found,

It is employed at the glass-houses, and added to the composition of which bottles are made. By the Germans it is called *Schwach* or *Schwartstein*; at the Swedish glass-works, *Trappskiol*, *Tegelskoil*, or *Swartskoil*; and at Jarlsberg in Norway, *Blabest*. In the air it decays a little, leaving a powder of a brown colour; it cracks commonly in the fire, and becomes reddish brown if made red hot. It is found

1. Of coarse chaffy particles, *Particulis majoribus acerosis*.
   - *a.* Dark grey, from the top of Kinnekulle in the province of Westergottland.
   - *b.* Black, from Stallberget at Ostersilfverberget in the province of Dalarne.
2. Coarse-grained, *Particulis majoribus granulatis*.
   - a. Dark grey, from the uppermost stratum at Hunneberg in Westergottland.
   - *b.* Reddish, from Bragnas in Norway.
   - c. Deep brown, from Gello in Norway.
3. Of fine imperceptible particles, *Particulis impalpabilibus*.
   - *a.* Black. The touchstone, *Lapis Lydius*, from Salberg mine, Hellefors Westersilverberget,

found, where no appearance of fused matters can be discovered, they must be attributed to the great convulsions and revolutions of this globe, already hinted at in the note to p. 486; which have overthrown, and even transported to very distant places of the earth, where no other volcanic traces can be found, very large tracts and mountains of basaltes, trapp, and lavas, after they have been formed by anterior eruptions of volcanic fires, &c.

 The

berget, and Norberg in Westmanland, and Ostersilverget in Dalarne, &c. [b]

b. Blueish, from Ostersilfverberget.

c. Grey, from Dalwik in the parish of Sorberke in Dalarne.

d. Reddish, from Dalstugun in the parish of Rettwik in Dalarne.

The texture of the trapp is either coarse, rough, and distinct, in its aggregate parts, or else they are fine and indiscernible. This last sort is often redish, always opake, and moulders by exposure to the air. Some of its specimens give fire with steel very difficultly, though it is always very compact. It looks sometimes as sprinkled over with a few minute shining particles.

Its specific gravity is $=3,000$. It is generally invested with a ferrugineous crust; and is often crystallised in opake triangular, or polyangular, columns. In this case it is called by the name of *Basaltes*: but that which is amorphous, or breaks in large, thick, square pieces, is called by the general name of *Trapp*.

When heated red hot, and quenched in water, it becomes by degrees of a reddish brown colour.

It melts *per se*, in a strong heat, into a flag.

Borax dissolves it by fusion in the *dry way*; but mineral alkaly does not entirely. *The Editor.*

[b] The black variety (3. *a.*) is sometimes found so compact and hard, as to take a polish like the black agate; it melts, however, in the fire to a black glass, and is, when calcined, attracted by the loadstone. Such a kind is found in the parish of Arla in the province of Sodermanland. *The Author.*

The touch-stone, or *Lapis Lydius*, has ever been, and is still now, one of the costly toys of filly *virtuosi*. Any black pebble, or a piece of black flint, does the same service as the very best *Lapis Lydius* of Asia. Even a piece of glass, made rough with emery, is successfully employed by our market dealers to distinguish gold pieces from counterfeits, both by the metallic colour, and by the test of *aqua fortis*. The Editor.

SECT. 411. (268.)

H. *Amygdaloides. Saxum basi jaspidea martiali, cum fragmentis spati calcarei et serpentini, figurâ ellipticâ* [a]. Mandelstein of some.

It is a martial jasper, in which elliptical kernels of calcareous spar and serpentine-stone are included.

a. Red, with kernels of white limestone, and of a green steatites, from Gello and Gullo in Norway, and the Hartz in Germany.

This is of a particular appearance, and when calcined is attracted by the loadstone; it decays pretty much in the air, and has some affinity with the Trapp (Sect. 410.) and also with the porphyry (Sect. 409.) There are sometimes found pieces of *native copper* in this stone at Gullo.

[a] These are the *carpolithi*, or fruit-stone rocks of the Germans, D. C. Bertrand asserts, that the *Amygdaloides*, or *Amygdalites*, are those stones which appear to be composed of such elliptical figures as petrified almonds, although in fact they are nothing else but small oblong pieces of calcareous stone, rounded by common attrittion, and sometimes small muscle-shells, connected by a stony concretion. But the *carpolithi*, or fruit stone rock, is a general name given, by the fossil writers, to all sorts of stony concretions which represent any fruit whatever, of a larger, or smaller, size than almonds commonly are. *See Bertrand's* Universal Dictionary of Fossils. *The Editor.*

SECT.

SECT. 412. (269.)

I. The *Greonsten* of the Swedes. *Saxum compositum mica et hornblende.* Sect. 137.

Its basis is hornblende, interspersed with mica. It is of a dark green colour, and is dug in several places in Smoland, where it is employed in the iron furnaces, as a flux to the bog ore (Sect. 335.) It is also found in other places, as at Rettwik in Dalarne, and in the neighbourhood of some of the iron mines.

SECT. 413. (270.)

K. The granites. *Saxum Compositum;* feltspato mica and quartzo, *quibus accidentaliter interdum* hornblende, steatites, granatus et basaltes *immixta sunt* [a].

Its

[a] The granite is called also *Moor-stone* in England: it consists of distinct masses of various stones mentioned by the noble author, or the greatest part of them, firmly compacted together. Their proportion and size are extremely variable, as well as their colour. The *quartz*, *feltspar*, and *mica*, constitute the hardest sort of granite, the most anciently known. That into which the *shoerl* enters, is more subject to decomposition. The granite never has any particular texture or regular form, but consists of enormous shapeless masses, of great hardness.

Its principal constituent parts are *felt spar* or *rhombic-quartz*, *mica*, and *quartz*.

It is found.

1. Loose or friable, *Particulis constans parum coherentibus.*

This is used at the brass works to cast the brass in, and comes from France.

2. Hard and compact, *Granites durus.*

a. Red.

1. Fine-grained, from Swappawari at Tornea in Lapland.

2. Coarse-grained, from Bispbergs Klack, in the province of Dalarne.

b. Grey,

In the finer granites, the *quartz* is transparent; in others generally white or grey, violet or brown. The *feltspar* *white*, *yellow*, *red*, *green*, or *black*, is generally the most copious ingredient. The *mica* is also *grey*, *brown*, *yellow*, *green*, *red*, *violet*, or *black*, and is commonly least copious. The *shoerl* is generally *black*, and abounds in the granites that contain it.

Hence the colour of granites chiefly depends on that of the spar or shoerl. The *red* granites consist commonly of white quartz, red feltspar, and grey mica. The *grey* of white quartz, grey or violet feltspar, and black mica. The *black* commonly contain shoerl instead of feltspar: and the *green* commonly contain green quartz.

If granite be exposed to the flame, urged by a blow-pipe, its different concretions separate from each other. In a crucible, Mr. Gerhard found the feltspar of a piece of granite melted into a transparent glass; under it the mica lay in the form of a black slagg. and the quartz remained unaltered. But when all three were powdered and mixed, it melted somewhat better; yet still the quartz may be distinguished by the help of a lens. This well explains why small white grains are frequently found in lavas. The experiments of Mess. d'Arcet and Saussure perfectly coincide on this subject.

The

b. Grey, with many and various colours, found on the coast round Stockholm and Norland.

The Granites are seldom flaty or laminated, when their texture is close, and the harder particles, as the feltspat or rhombic quartz, the quartz, and the shirl, predominate in it. They admit of a good polish, for which reason the Egyptians in former times, and the Italians now, work them into large pieces of ornamental architecture, for which purpose they are extremely fit, as they do not decay in the air.

The mixture of mica prevents the silex or quartz from cracking or splitting; and hence its infusibility and advantageous use in furnaces.

The *granitone*, mentioned by Ferber in his letters from Italy, is a stone composed of *feltspar* and *mica*. A substance of this kind, which moulders by being long exposed to the air, is found in Finland; it is said to contain sometimes *saltpetre*, and sometimes *common-salt*. It is there called *Rapakivi*. Wallerius describes 18 species of granites, besides many other granatic stones, on which the curious reader may consult his Mineralogic System of the edition in 1778. *The Editor, chiefly from* Kirwan.

SECT. 414. (271.)

2. Conglutinated Saxa, *Saxa conglutinata.*

A. Of larger or broken pieces of ftones of the fame kinds conglutinated together, *Saxum conglutinatum fragmentis lapidum. Breccia* [a].

1. Of

[a] The Stones called *Ludi Helmontii*, or *Paracelfi*, have fome fimilarity, in their form, to the *brecciæ* of this Section; for they are compofed of various lumps of a marly whitifh-brown matter, feparated into a great number of polygonous compartments, of various fizes, formed of a whitifh-yellow cruft of a red calcareous fpar, fometimes pyritous, which often rife a little above the external furface, and inclofe each of them on the infide. According to Bomare, the *Ludus Stellatus Helmontii*, found in the county of Kent, is covered with a kind of ftriated felenite, refembling the zeolite.

They are for the moft part of a globofe figure, feldom flat, but often convex on the outfide. And fometimes with a concave furface.

According to Wallerius, the *Ludus Helmontii* lofes by calcination about half of its weight; and, on being urged by fire, is melted into a black glaffy flag. It effervefces ftrongly with *aqua fortis*, and this folution is of a yellow colour. But what feems very extraordinary, by adding to it fome oil of tartar *per deliquium*, bubbles are produced, from which a great number of flender black threads, or filaments, are produced, fticking like a cobweb to the fides and bottom of the veffel.

Thefe ftones are found quite feparate by themfelves, as well as various *ftalagmites* and *cruftaceous bodies*, on the ftrata of argillaceous earth, in various parts of Europe, chiefly in Lorrain, Italy, England (in the counties of Middlefex and Kent), and elfewhere.

Wallerius

1. Of limestone cemented by lime, *Saxum constans fragments lapidis calcarei, calce conglutinatis.*

a. The calcareous Breccia, *Breccia calcarea*; The *Marmi Brecciati* of the Italians.

When these kinds have fine colours, they are polished and employed for ornaments in architecture, and other œconomical uses; they come from Italy.

b. The *Lumachella* of the Italians, or shell marbles. These are a compound of shells and corals, which are petrified or changed into lime, and conglutinated with a calcareous substance. When they have many colours, they are called marbles, and employed for the same purposes as the preceding, likewise from Italy, from Bergen in Norway, and Offerdal in the povince of Jemteland. In the island of Gottland there is found one of this kind of one colour only, which on that account is not called marble, or used as such. At Balsberget in the province of Skone, is found of a white lumachella, of weak colours.

Wallerius ranges the *Ludus Helmontii* among the *tophi*, in the *Spec.* 425, of his System of Mineralogy. Paracelsus had attributed to these stones a *Lithontriptic* power, and Dr. Grew says, that they are *diuretic*; but there is not the least proof of their really possessing such qualities. *The Editor.*

SECT.

SECT. 415. (272.)

2. Of kernels of jasper cemented by a jaspery substance, *Saxum fragmentis jaspidis materiâ jaspideâ conglutinatum. Breccia Jaspidea. Diaspro brecciato* of the Italians.

Of this kind specimens from Italy are seen in collections. A coarse Jasper Breccia is said to be found not far from Frejus in Provence in France.

SECT. 416. (273.)

3. Of siliceous pebbles, cemented by a jaspery substance, or something like it, *Saxum silicibus amorphis materiâ jaspideâ conglutinatis.* The plum-pudding stone of the English. *Breccia Silicea.*

Its basis, which is likewise the cement, is yellow, wherein are contained single flinty or agaty pebbles, of a grey colour or variegated. This has a very elegant appearance when cut and polished. It is found in England.

SECT. 417. (274.)

4. Of quartzose kernels combined with an unknown cement, *Saxum fragmentis quartzosis conglutinatis. Breccia quartzosa.* Found in the provinces of Jemteland and Smoland.

SECT. 418. (275.)

5. Of kernels of several different kinds of stones, *Saxum fragmentis variorum saxorum conglutinatis. Breccia saxosa.*
   a. Of kernels of porphyry, cemented by porphyry or a coarse jaspery sustance, *Breccia porphyrea*, from Serna Fiell, and Hykieberget in the province of Dalarne.
   b. Of kernels of several saxa, *Saxum fragmentis variornm saxorum compositorum conglutinatis. Breccia indeterminata* [a].

[a] The above mentioned Bricciæ require the distinctions here made between them, but which perhaps may seem to be carried too far, since their particles are so large and perfect as to be easily known from one another. These stones are a proof both of those subversions which the mountains in many centuries have undergone, and of some hidden means which nature makes use of in thus cementing different kinds of stones together. Any certain bigness for the kernels or lumps in such compounds, before they deserve the name of Breccia, cannot be determined, because that depends on a comparison which every one is at liberty to imagine. At one place in the mountain called Hykieberget, the kernels of porphyry have a diameter of six feet, while in other places they are not bigger than walnuts. At Massewala the kernels have a progressive size down to that of a fine sandstone. Most of this kind of stone is fit for ornaments, though the workmanship is very difficult and expensive. *The Author.*

Is

b. Of no visible particles, from France and Livonia. This is of a loose texture, and hardens in the air.

3. With an unknown cement, *Lapis arenaceus glutine incognito, forsan argillaceo.*

a. Loose, from Helsingberg in Skone.

b. Harder, from Roslagen, Orsa, and Kinnekulle.

c. Compact, from Gesle in the province Gestrikeland, and the lake Malaren.

d. Very hard, from Serna Fiell or Fells in Dalarne; it is also found in great abundance in loose stones at Gustavsstrom, and at Siliamfors in the parish of Mora in Dalarne.

4. Cemented by rust or ochre of iron, *Lapis arenaceus ochrâ martis conglutinatus.* Is found in form of loose stones at several places, and ought perhaps to be reckoned among the *Mineræ Arenaceæ* or Sand-Ores of Sect. 420; at least when the martial ochre makes any considerable portion of the whole.

SECT.

There are many quarries of sandstones in Sweden, but no enquiry has been made if any of them, and which can be employed in the larger works, instead of the English, and in the smaller manufacturies, instead of the Bohemian sandstones. Such enquiries are of greater consequence, in proportion as those manufactures increase wherein they are wanted.

It must be remarked, that the working masons, or stonecutters, ought to wear a piece of frieze or baize before their mouth and nose, in order to preserve themselves from a premature death, which is unhappily at present the case with them in the parish of Orsa in Dalarne, and in other places.

But

them cannot easily be discovered by the naked eye. The greatest part, however, consist of quartz and mica, which substances are the most capable of being granulated without being brought to a powder.

I think I have reason to consider this kind in regard to the substance which has served as a cement to combine them, although it is not always perfectly discernible.

1. Cemented by clay, *Lapis arenaceus glutine argillaceo.*

a. With an apyrus or refractory clay, *Argillâ porcellaneâ.*

It is found under the stratum of coal in the coal-mine at Boserup in Skone; is of a loose texture, but hardens, and is very refractory in the fire.

b. With common clay, *Argillâ communi*, from Burswick in the island of Gottland.

2. With lime, *Lapis arenaceus glutine calcareo*; resembles mortar made with coarse sand.

a. Consisting of transparent and greenish grains of quartz and white limestone; from the island Iso, near Beckaskog in Skone.

b. Of

in its texture, it is nevertheless unfit for buildings which are exposed to fire or open air, because it breaks to pieces and melts in the fire, and in the air it attracts the moisture, decays in process of time, and cracks in the cold, which proceeds from the included kernels of clay expanding themselves when they grow wet. Sand-stones ought therefore to be very nicely examined before they are employed for the usual purposes.

There

SECT. 421. (278.)

a. Of smaller pieces, *Granulis lapidum et minerarum* [a].

a. Potters lead ore with a quartzose sand, from Eiffelsfeldt near Cologn in Germany.

b. Mountain green with sand, from Siberia.

c. Cobalt ore with sand.

d. Martial ochre with sand.

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[a] The *Mineræ Arenaceæ* or Sand-ores, cannot reasonably be separated from the sand-stones, since they are produced in the same manner; besides, when they are poor in yield, they are also employed to the same purpose, because it is not easy to smelt the metal out of them. The sand-ores, besides, cannot be ranked in a Mineral System as separate species of ores, because they would then be arranged with respect to the kind of stone in which the ore occurs, and not the ore itself, which case cannot be admitted here. It might be urged, that ores, mixed with the stones of the very load, and not in form of sand ores, ought as well as them to be ranked among the compound saxa: but in that case there would be no end of species, nor could they ever be reduced into any order. *The Author.*

SECT.

SECT. 422. (279.)

OBSERVATIONS on the SAXA or STONES.

Besides the advantages which may accrue to œconomy by a perfect knowledge of the Saxa, the miners or subterranean geographers expect also another future benefit from it, viz. that of concluding, from many observations, whether all the Saxa are to be equally attended to; for example, whether in some of them veins or strata of ores may be expected, and whether those are only of certain kinds; whether others are every where found destitute of any ore whatsoever; which of them are observed to form coats on the surface of the rock, that cover other kind of stones, or veins and strata of ores, &c. If no general rules can be deduced from such observations, there is a probability, at least, of gaining some knowledge that may be peculiar to certain countries; and this opinion is already in some places confirmed by experience. Hence it may be concluded, how necessary it is to communicate all such observations which, for the abovementioned purposes, ought to be made over the whole globe, and also to agree on fixing certain names on the *Saxa*, in order to avoid too great a prolixity in their descriptions. It is with this intention I have here, as a ſpecimen, given ſpecific names to thoſe Saxa which are found in this northern country, and are known to me, wiſhing at the ſame time to be acquainted with a method to diſtinguiſh them more eaſily and to better purpoſe.

This procedure will be found ſtill more neceſſary and uſeful, as the world ſeems reſolved ſoon to aboliſh the ſuperſtition of the Hazel Rod or *Virgula Divinatoria*, and that we have by means of obſervations already gained too much experience to believe, that the ſtrata of earths and ſtones are placed equally and in the ſame order and ſituation over the whole earth; which ſome, however, in theſe our times have even endeavoured to prove, while others have made a ſecret of it, in hopes of enriching themſelves.

SECT. 423. (280.)

The SECOND ORDER.

MINERAL-CHANGES, or the PETRIFACTIONS.

Mineralia-Larvata, vulgo *Petrefacta* [a].

Are mineral bodies in the form of animals or vegetables, and for this reaſon no others belong to

[a] The Noble Author has very judiciouſly confined to the 13 following ſmall Sections, all that is worthy of being known by mineralogiſts about petrifications, a ſubject upon which

to this order, than such, as have been really changed from the subjects of the other two kingdoms of nature.

There is more difficulty to determine the first point, viz. from when these bodies are to be styled petrefactions, than from when they cease to be such; meanwhile I have, in order to make a trial, considered them in the following manner.

SECT.

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which many voluminous works have been given to the public, with immense labour and erudition, tho' both were very idly employed. The celebrated Wallerius, not to mention his numberless predecessors of the same stamp, has had the patience, to employ no less than 270 pages of his Mineralogy, with an account of the *concrete*, *figured*, and *petrified fossils*, above half (189 pages) of which he has intirely devoted to the last kind of bodies. But what is very remarkable, and must excite the smiles of a sober reader, is the pompous Greek nomenclature that has been bestowed upon such trifling and childish objects: *phytotypolithes*, *meandrites*, *entomolithes*, *apomosostomes*, *orthoceratites*, &c. are to express *petrified* plants, coralloides, crabs, echinites, and shells of sea-insects. I shall forbear to make any additional notes about these matters. But the curious may easily apply for information to the *Oryctology*, or *Dictionary of Fossils*, published in French by E. Bertrand at the Hague, in 1763, in 2 vols in 8vo.; and to some other authors on the subject. *The Editor.*

The most remarkable observations, relative to petrifications, are,

1. That those of *shells*, are found on or near the surface of the earth; those of *fish* deeper, and those of *wood*, deeper still. Shells in *specie* are found in immense quantities at considerable depths.

2. That those organic substances that resist putrefaction most, are frequently found petrified, such as *shells*, and the harder species of *woods*. On the contrary, those that are aptest to putrify, are rarely found petrified, as *fish*, and the softer parts of *animals*, &c.

 3. That

SECT. 424. (281.)

1. Earthy Changes, *Terræ Larvatæ. Terrificata.*

A. Extraneous bodies changed into a lime substance, or calcareous changes, *Larvæ calcareæ.*

1. Loose or friable, Chalky changes, *Cretæ larvatæ.*

a. In form of vegetables.

b. In form of animals.

1. Calcined or mouldered shells, *Humus conchaceus*, from the province of Helsingeland, at Uddevalla in the province of Halland, and in the French strata of earth and chalk.

2. Indurated, *Petrefacta calcarea.*

a. Changed and filled with solid limestone.

1. In form of animals.

2. In form of vegetables.

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3. That they are most commonly found in strata of marl, chalk, lime-stone, or clay: seldom in sand-stone; still more rarely in gypsum; but never in gneiss, granite, basaltes, or shoerl. But they sometimes occur among pyrites, and ores of iron, copper, and silver; and almost always consist of that species of earth, stone, or other mineral, that surrounds them; sometimes of silex, agate, or cornelian.

4. That they are found in climates, where their originals could not have existed.

5. That those found in *slate*, or *clay*, are compressed and flattened. *The Editor from* Kirwan.

Found

Found in the iſland of Gottland.

b. Changed into a calcareous ſpar, *Petrefacta calcarea ſpatoſa.*

1. In form of animals.

The ſhells in Balſberget in the province of Skone.

2. In form of vegetables [*b*].

SECT. 425. (282.)

B. Extraneous bodies changed into a flinty ſubſtance. Siliceous changes, *Larvæ.* Theſe are like the flint,

[*b*] Shells and corals are indeed compoſed of limy matter, even when their animals ſtill dwell in them; nevertheleſs, although they are not changed in regard to their principle, yet they are reckoned among the petrefactions, as ſoon as the particles of the calcareous ſubſtances have obtained a new ſituation; for example, when they are become ſparry, when they have been filled with a calcareous earth, either hardened or looſe, or when they lie in the ſtrata of the earth. Theſe form the greateſt part of foſſil collections, which are ſo induſtriouſly made, often without any regard to the only and principal uſe they can be of, viz. that of enriching zoology. Mineralogiſts are ſatisfied with ſeeing the poſſibility of the changes the lime-ſtone undergoes in regard to its particles, and alſo with receiving ſome inſight into the alteration which the earth has been ſubject to, from the ſtrata which are now found in it.

The calcined ſhells, or thoſe which have been changed into limy and chalky matter, are fit to make lime, and are ſtill more ſerviceable as a manure. The indurated ſerve only to make grottos. No gypſeous petrefactions are known, if ſuch are not found in the Perſian alabaſter; for Mr. Chardin ſays, that he has ſeen a lizard included in that ſtone. *The Author.*

 1. Indurated,

1. Indurated, *Petrefacta silicea.*
a. Changed into flints.
1. Carnelians in form of shells, from the river Tomm in Siberia.
2. Agat in form of wood. Such a piece is said to be in the collection of Count Tessin.
3. Coralloids of white flint, (*Millepora*) found in Gottland.
4. Wood of yellow flint. Italy, Adrianople, and Loughneagh, a lake in Ireland.

SECT. 426. (283.)

C. Extaneous bodies changed into clay. Argillaceous changes, *Larvæ argillaceæ.*
a. Loose and friable.
1. Of porcellane clay.
a. In form of vegetables.

A piece of white porcellane clay from Japan, with all the marks of the root of a tree, has been observed in a certain collection.

b. Indurated.
1. In an unknown clay. *See page* 77. *a.*
a. In form of vegetables. *Osteocolla:* It is said to be changed roots of the poplar tree, and not to consist of any calcareous substance. See the *Physicaliche Belustigugen.*

A sort of fossil ivory is said to be found, which has the properties of a clay; but I do not know if it is rightly examined.

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SECT. 427. (284.)

2. Saline extraneous bodies, or ſuch as are penetrated by mineral ſalts, *Corpora peregrina inſalita. Larvæ inſalitæ.*

A. With the vitriol of iron, *Vitriolo martis inſalita.*

1. Animals.

a. Human bodies have been twice found in the mine at Falun in Dalarne; the laſt was kept a good many years in a glaſs caſe, but began at laſt to moulder and fall to pieces.

2. Vegetables.

a. Turf, and

b. Roots of trees.

Theſe are found in water ſtrongly impregnated with vitriol; for inſtance, in the moor at Oſterſilfberget in Dalarne. They do not burn with a flame, but only like a coal in a ſtrong fire; neither do they decay in the air.

SECT. 428. (285.)

Extraneous bodies penetrated by mineral inflammable ſubſtances, or mineral phlogiſton, *Corpora peregrina phlogiſtis mineralibus impregnata.*

A. Penetrated by the ſubſtance of pit-coal, *Lithantrace impregnata.*

1. Vegetables, which commonly have been woods, or appertaining to them.

a. Fully ſaturated. *Gagas. Jet. See Sect.* 240. *p.* 473.

The jet is of a ſolid ſhining texture. From England, Boſerup in Skone, and the Black Sea.

b. Not perfectly ſaturated. *Mumia vegetabilis.* Is looſe, reſembles umbre, and may be uſed as ſuch. From Boſerup.

SECT. 429. (286.)

B. Penetrated by rock oil or aſphaltum, *Corpora peregrina petroleo ſeu aſphalto impregnata.*

1. Vegetables.

a. Turf in the province of Skone.

The Egyptian mummies cannot have any place here, ſince art alone is the occaſion that thoſe human bodies have in length of time been penetrated by the aſphaltum, in the ſame manner as has happened naturally to the wood in pit-coal ſtrata (Sect. 428.)

SECT. 430. (287.)

C. Penetrated by ſulphur which has diſſolved iron, or by marcaſite and pyrites, *Pyrite impregnata. Petrefacta pyritacea.*

1. Human.

1. Human.
   a. Bivalves,
   b. Univalves, and
   c. Insects.
   In the alum slate at Andrarum in Skone.

SECT. 431. (288.)

4. Metals in the form of extraneous bodies, *Larvæ metalliferæ*.
   A. Silver, *Larvæ argentiferæ*.
1. Native.
   a. On the surfaces of shells. England.
2. Mineralised with copper and sulphur.
   a. Fahlertz or grey silver ore (Sect. 272. and 276.) in form of ears of corn, &c. and supposed to be vegetables, are found in argillaceous slate at Frankenberg and Tahlitteren in Hesse.

SECT. 432. (289.)

B. Copper, *Larvæ cupriferæ*.
   1. Copper in form of calx, *Cuprum calciforme corpora peregrina ingressum*.
   a. In form of animals, or of parts belonging to them.
1. Ivory, and other bones of the elephant. The Turquois or Turky stone: It is of a blueish

blueish green colour, and much valued in the East. *See Sect.* 323, *p.* 686.

At Simore in Languedoc bones of animals are dug, which during the calcination assume a blue colour; but it is not probable that the blue colour is owing to copper.

SECT. 433. (290.)

2. Mineralised copper, which impregnates extraneous bodies, *Cuprum mineralisatum corpora peregrina ingressum.*

A. With sulphur and iron. The yellow or marcasitical ore that impregnates

1. Animals.

a. Shells, from Hagatienns Schurff and Jarlsberg in Norway. These shells lye upon a loadstone,

b. In form of fish, from Eeisleben, Mansfeld, and Osterode, in Germany.

B. With sulphur and silver. Grey silver ore at Fahlertz, like ears of corn, from the slate quarries in Hesse (Sect. 431.)

SECT. 434. (291.)

C. Changes into iron, *Larvæ ferriferæ.*

1. Iron in form of calx, which has assumed the place or the shape of extraneous bodies, *Ferrum calciforme corpora peregrina ingressum.*

a. Loose,

a. Loose, *Larvæ ochraceæ.*

1. Of vegetables.

Roots of trees, from the lake Langelmä in Finland: *See the* Acts *of the* Swedish Academy of Sciences *for the year* 1742.

b. Indurated, *Larvæ hæmatiticæ.*

1. Of vegetables.

Wood, from Orbissau in Bohemia.

SECT. 435. (292.)

2. Iron mineralised, assuming the shape of extraneous bodies, *Ferrum mineralisatum corpora peregrina ingressum.*

a. Mineralised with sulphur. Marcasite. *Larvæ Pyritaceæ.* Sect. 430.

SECT. 436. (293.)

4. Extraneous bodies decomposing, or in a way of destruction, *Corpora peregrina in gradibus destructionis considerata.* Mould, *Humus.* Turf, *Turba.*

A. From animals. Animal mould, *Humus animalis.*

1. Shells. *Humus conchaceus.*

2. Mould of other animals, *Humus diversorum animalium.*

B. Vegetable mould, *Humus vegetabilis* [c].

1. Turf,

[c] All the kinds of mould contain some of the inflammable substance, which has remained in them from the vegetables or animals; and they are more or less black, in proportion as

1. Turf, *Turba.*

a. Solid, and hardening in the air, *Turba solida aëre indurescens.* Is the best of this kind to be used for fuel, and comes nearest to the pit-coals. It often contains a little of the vitriolic acid.

b. Lamellated turf, *Turba foliata.* This is in the first degree of the destruction.

2. Mould of lakes, *Humus lacustris.* This is a black mould, which is edulcorated by water.

3. Black mould, *Humus ater.*

This is universally known, and covers the surfaces of that loose earth in which vegetables thrive best.

SECT.

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as they contain more or less of this phlogiston. I have ranked them in this place, that they might not be totally excluded. They are else a *medium uniens* between all the three kingdoms of nature: and it may reasonably be asked, if all sorts of earth do not in form of very minute particles enter into the composition of vegetables and animals, after which they exist for some time in form of mould, until the phlogiston is again separated. *The Author.*

The black mould yields by distillation an oily and alkaline substance. *Humus atra* (says Wallerius) *destillatione dat* phlegma, *plus minus pro ratione siccitatis*; 2. Spiritum acrem fœtidum, *qui quo obscuriori destillat colore, eo magis acris & empyreumaticus, non tamen* salinus, *utpote nec cum* acidis *nec cum* alkalinis *effervescens, sed oleosus* spiritui tartari *odore et sapore similis*: 3. *Et denique* quidpiam oleosi rubentis.—*In English.* The black mould affords, when distilled, more or less phlegm, according to the degree of its dryness: 2dly, a sharp fetid liquor, which is more acid and empyreumatic in proportion as it is of a darker colour: but it neither effervesces with acids nor alkalis; has an oleaginous appearance, and resembles, both in taste and smell, the spirit of tar-

tar

SECT. 437. (294.)

The THIRD ORDER.

NATURAL SLAGS,

Scoriæ Vulcanorum [d].

Slags are found in great abundance in many places in the world, not only where volcanos yet

tar and lastly, a small quantity of a reddish oil. *The Editor.*

[d] 1. Volcanos, or burning mountains, are peculiar to no climate, and have been observed in every quarter of the globe, as Kirwan observes. They have no necessary or regular connection with those of other mountains; it seems, however, that the contrary is sometimes the case, as mount Ætna, or Gibello, in the island of Sicily, has been observed to have made some extraordinary explosions, when Vesuvius in Italy was in its greatest convulsions.

2. These burning mountains are of various sizes, that of *Tana* in the Pacific Ocean is no higher than 450 feet; but others of the kind are considerably high. Ætna in the island of Sicily is above 24 times higher, *viz.* 10,954 *feet*, according to what is said in the Phil. Transf. vol. 67. p. 595. These mountains generally form lofty spires internally shaped like an inverted cone, placed on a broad basis, which is upwards; this is called the *Crater* of the Volcano, and through it the lava and other ejected matters generally pass; though it sometimes bursts from the sides, and even from the bottom of the mountain. Sometimes, also the crater falls in, and is effaced. In extinguished volcanos it is often filled with water, and forms those lakes that are observed on the summits of various mountains.

5 3. Both

yet exist, but likewise where no subterraneous fire is now known. Yet, according to our opinions, they cannot be produced but by means of

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3. Both the crater, and basis of many volcanos, consist of lavas, either solid and intire, or decomposed, nearly as low as the level of the sea: but they finally rest upon *granite*, as the volcanos of *Peru*; or on *Shistus*, as the extinguished volcanos of *Hesse* and *Bohemia*; or, finally, on *lime-stone*, as those of *Silesia*, the *Vicentine Alps*, and mount *Vesuvius* in Italy. The decomposed and undecomposed lavas form irregular strata, that are never parallel to each other; and, besides *iron*, of which they contain from 20 to 25 *per cent*. *sulphur*, and some fragments of *copper*, *antimony*, and *arsenic*, they contain no other ores.

4. The immense quantities of matter thrown up, at different periods, by volcanos, without lessening the apparent bulk of their mountains, shew that the seat of these fires must be several miles, perhaps hundreds of miles, below the surface of the sea; and in fact there are records of various volcanic explosions under the bottom of the sea, one of which happened a few years ago near Iceland. And, as *iron* makes from $\frac{1}{5}$ to $\frac{1}{4}$ of all these ejections, we may infer, that the interior parts of the earth consist chiefly of this metal, its ores, and those stones that contain it, whose greater or lesser dephlogistication in different parts may cause the variation of the magnetic direction in various places of the globe.

5. It is well known that martial pyrites, being moistened, acquire heat, and if there be the concourse of pure air, it will burst into actual flame; but when there is no such communication, we may suppose that the heated pyrites may be in contact with *black wad* (pag. 859), and *petrol* (Sect. 236. and that the flame may be fed by the *vital* or *dephlogisticated air* that is produced from those substances which are known to afford it, in the same manner as nitre is employed to entertain the flame in the modern manufactories of *vitriolic acid*.

6. As to the explosion or eruption of the melted and scorified matters thrown out by the volcanic mouths, it may naturally arise from large quantities of water, which enter by some cracks,

of fire. These are not properly to be called natural, since they have marks of violence, and of the last change that mineral bodies can suffer

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cracks, and hollow communications, formed by the weathering of the interior veins of soft substances between the mountains and the sea, rivers, or sources of water, in the neighbourhood of them; or else the water may be naturally produced within those enormous cavities on the inside of the volcanic mountains; since it has been lately discovered (or at least asserted) by some naturalists, that this fluid substance may be formed by the intimate union and deflagration of *inflammable* and *dephlogisticated air*.

7. If the mass of the water be sufficiently great, it will extinguish the fire that had been lighted. On the contrary, if the water be in a less proportion, it will suddenly be converted into vapour, whose elastic force is known to be several thousand times greater than that of gun-powder. If the superincumbent weight be too great, it may cause earthquakes; but it will propel both the melted and diluted matters laterally towards the mouth of the volcano, where, meeting with the least resistance, it will expel them, together with all the unmelted stony masses it meets with in its passage.

8. It is easily conceived, that before the dense, soaked, and fused matters be ejected, the expanded air of the volcano will first be forced out, and carry with it the ashes and looser stones adhering to its sides and crater, as have been observed by eye witnesses, and various historians, to great distances. In the explosion of Vesuvius, on March 31, 1767, there were large blocks of stone, above 20 tons or 40,000 pounds weight, blown above 200 feet high according to Hamilton, and 1200 feet according to de la Torre. Bergman speaks of a rocky block of about 1000 cubic feet thrown to the distance of half a Swedish mile. The ashes of the eruptions, in 1631, went so far as *Ragusa*, *Sardinia*, and even to *Constantinople*, as Braccini asserts, quoted by B. Dietrich, in his notes to *Ferber's Letters*, where an account of the prodigious quantity and varieties of these volcanic ejections may be seen.

9. But

suffer without the destruction of the world; nor are they artificial according to the universally received meaning of this word. When we

9. But the basaltes, among these volcanic products, deserves to be mentioned in a more particular manner. Our author thought that they belonged to a very different kind, and confounded them with the shoerls, as appears by his 72d and following sections, at p. 207, and following, of his edition, where he called the Shoerl, or *Lapis Corneus* of *Wallerius's* first edition, by the name of *Basaltes*. Bergman, in the Sect. 120 of his *Sciagraphia*, pointed out this impropriety, which has been corrected in the present edition.

10. Pliny, in his 36 book, chap. 7, asserts, that the *basaltic stone* had been discovered by the Egyptians in Ethiopia; 2dly, that the name of *Basaltes* had been given to it; and 3dly, that it possessed both the colour and hardness of iron.

11. Bergman, Guetard, Kirwan, and other philosophers, seem to have decided, upon very plausible reasons, which the first named philosopher has judiciously exposed in his Treatise de *Productis Vulcanicis*, that the basaltes have been formed in the *humid way*, from the fluid matters formerly ejected by volcanos: but Desmarest, Ferber, Baron de Dietrich, de St. Fond, and other learned men, are of opinion, that the formation of these wonderful masses were produced *via sicca*, from the melted or fused matters ejected by the same vulcanos. The basaltic substance is indeed far from the true vitreous state; and, when urged by fire, it runs into a black glass, whose texture has not the least resemblance to that of its crude state.

12. Basaltes are found in two or three general forms; either amorphous in masses of all sizes and thickness. Sometimes lamellated like slate, and of large dimensions, and at other times very thick, forming solid blocks from the smallest size to that of the whole mountains. The trapp, already mentioned in Sect. 410, is of this kind.

13. The most remarkable basaltes are those of a columnar form; they are properly *polyhedrical* and polygonal, being composed of flat sides, which form a great variety of angles between themselves; but they cannot be called *crystalised*,

we perhaps in future times by new discovered means may be able to find out of what sort of earth stones are compounded, we shall still be forced

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ised, because they never exhibit any regular figure or symmetrical dispositicn of parts, and of course they cannot be ranked among *crystals* or *crystallised* bodies. Some, though very rare, have a cylindrical form, like columns, so that the transverse section is a true circle, and even some have been found of a flattened shape, having an ellipsoide for their lateral section.

These polygonal columns consist of many sides, from 3 to 11, and sometimes more, seldom forming similar angles; and as to their size, they vary very much. Some are found, though very rarely, so small as to deserve the name of miniature, *viz.* from 4 to 5 *tenths* in breadth to one inch and a half in length; but the most common sized ones are from 5 to 11 and more inches in diameter, and from 1 to 16, 25, and 30 feet high.

14. Bergman asserts, that basaltic columns have been found of 30, 40, and more feet high, and of enormous thickness. Many of great dimensions are found, as Faujas mentions, near the castle of *Bastide*, and in the mountain of *Chenevari*, in the province of *Viverais* in France, measuring, 3 ½ *feet* in thickness, and, 15 or 16 feet long. There are others still more voluminous in the *Expailli* of *Velai* in *Auvergne*, in the states of Venice, chiefly about *Vicenza* in *Sicily*, and in the province of *Antrim* in Ireland. One octogonal prism, from this last place, is kept in the *British Museum* of London, whose weight was guessed by Brunnich to be about 1300 pounds, and no doubt but much larger still may be found in the same and other places.

15. Solid bowls, or globes, and even of an oval form, have been found also, formed out of the basaltic substance. Some of an uniform mass, and others composed of concentric crusts, which may be separated by the blow of a hammer. A large and very singular one of this kind is represented in the last plate of the volcanic *Mineralogy of Faujas de St. Fond* printed in 1784. The natural process by which poligonous basaltes sometimes become of a spherical form, by losing their corners, was first observed by Messieurs the *Mar-*

 quis

forced to ſtop at the ſurface of them, and be contented with knowing that they contain a little

quis de Laizier, *Beſſon*, and *Delarbre*, in the mountains of Auvergne in France. *See the* account *given, by the laſt named gentleman, in* Journal de Phyſique, *for Auguſt* 1787, p. 135.

16. Another ſort of baſaltes ſhews a fibrous texture, like the Aſbeſtus, though their colour and component parts are like thoſe already deſcribed.

17. But the moſt numerous columnar baſaltes, in various countries, are of the articulated kind, each conſiſting of many ſmaller priſms of a ſhort and ſimilar form in their ſides, diſpoſed into the ſame number of angles, and under the ſame angular inclination to one another, terminated by two horizontal perpendicular baſes, of which one is concave and the other convex, having a roundiſh prominence in the middle, which fits exactly on the hollow of the next priſm. Theſe polygonous priſms, or columns, ſtand upright, and ſometimes variouſly inclined to the horizon; they ſtand very cloſe to one another, leaving only ſome chinks between themſelves, which ſeldom exceed the breadth of 4 or 5 tenths of an inch, and are filled for the moſt part with a calcareous ſpar, that often covers each priſm like a natural varniſh.

18. This circumſtance demonſtrates, that the volcanic lavas, which formed theſe baſaltic priſms, were firſt in a ſoft ſtate, and that either by ſimply cooling, or by the evaporation of ſome ſubtle mixture, they contracted their dimenſions, forming themſelves into all the varieties of polygonous priſms; ſuch as we obſerve in various ſimilar circumſtances. That kind of Indian ware from China and Japan, whoſe outſide ſurface is cracked into various ſmall polygons, may ſerve as a ſample in miniature of theſe phænomena: and I have ſeen a group of white artificial cryſtals, which aſſumed, by cooling in the oven, a baſaltic form. This laſt has been already mentioned by Sir Wm. Hamilton in the 2d part of Phil. Tranſ. for 1786, p. 375.

19. The calcareous ſpar, juſt now mentioned, ſeem to demonſtrate alſo, that when theſe volcanic fluid ſubſtances were ſettled, and had been already contracted in their dimenſions, they

little iron. Mean while I cannot omit them here, ſince I have conſidered the petrefactions;

they have then been overflowed by an inundation of diſſolved calcareous earth, which covered their ſurfaces, and filled their chinks with thoſe ſparry incruſtations. The ſame Sir Wm. Hamilton, to whoſe zeal we owe great elucidations on theſe ſubjects, affirms, that the lavas, which happened to run in their fluid ſtate to the ſea, from the *Etna*, and from the other volcanic mouths in the iſlands of *Lipari*, have aſſumed the form of priſmatic baſaltes.

2b. This regular and cloſe correſpondence of thoſe pieces, that form the horizontal ſurface of the baſaltes among themſelves, muſt leſſen the ſurprize of thoſe who travel in Italy, when they behold the many and extenſive parts of the *Via Appia*, and of other antient pavements ſtill remaining, through many miles, in various roads, in the neighbourhood of Rome, and other parts, formerly inhabited by the Romans. Theſe old pavements are compoſed of large brown or blackiſh angular ſtones, ſo well adapted to each other, that it ſhould require an immenſe labour to be framed by art; but the Romans undoubtedly got them in this form from ſome baſaltic quarries, ſuch as have been lately diſcovered in various parts of Italy. Nevertheleſs, the labour and expence, of extracting, carrying, and fitting them to their public roads, muſt have been extremely toilſome. The greateſt part of thoſe large tracts of ſimilar volcanic productions, not only in the Iriſh county of Antrim, but thoſe of Vivarais and Auvergne in France, in Italy, and in Germany, as well as in various other provinces of Europe, afford certainly the ſame conveniency for paving modern roads; but in all probability they never will vie, at leaſt by their durability, for ſo many centuries to come, with the R man ones. The ancient undertakings, even after ſo many ages, ſtill appear to have been made on a gigantic ſcale, whilſt the moſt magnificent attempts of our times only ſeem to be like the work of a race of puny pigmies, in compariſon to the antient monuments.

Baſaltes are of various colours; for the moſt part brown, or black, of different ſhades, ſome of as deep a *black* as the beſt ebony; ſome are *blueiſh*, *greeniſh*, *grey*, and of an ochreous *yellow*, or *reddiſh* colour; ſome are variegated with tions; and therefore I will enumerate some of them, according to their external marks.

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small spots of whitish shoerls, and of different colours; and some are *transparent* like glass, which last are employed with success in blackglass manufactories, for making bottles. To this last belong the *Lapis Obsidianus* of Pliny, the *Islandic Agate* of the next Section, and the *Lapis Gallinaçeous* from Peru, in the Spanish America, which by its beautiful blackness assimilates to a large black bird of the crow kind in that country, called *Gallinaço*.

22. Mr. Latrobe told me that he had seen in Upper Lusatia, in the manor of *Bertholsdorff* near *Herrnhut*, the chief settlements of the Moravian brethren, a rock of granite, which apparently bursts asunder by a vein of concentric basaltes. This seems to have a communication with a conic hill of considerable height, called the *Hutberg*, which consists of basaltes covered with mould, and has several parties of basaltic columns at the top: the country all around is covered with large blocks of granite.

23. There are also found basaltes, with other various extraneous bodies, inclosed in their masses, which equally shew the fused state they had originally suffered; among these are crystallized *shoerls*, both white and black, calcareous *spars*, *zeolites*, *crysolites*, *saphyrs*, *garnets*, pieces of *porphyry*, *granite*, and of other stones. But the shoerls and white garnets that are found imbeded within the mass of basaltes, they seem rather formed *via sicca*; as Ferber asserts, in his *eleventh letter*.

24. The mass which is formed into the basaltic shape, seems to be of the same very kind of the lava; but more elaborated, perhaps by a longer boiling, baking, or roasting, on the bowels or bottom of the vulcanic crater. Bergman, who analysed various masses of basaltes, found that at a *medium*, their component parts consist of 52 parts, or hundreds of *siliceous earth*; 15 of *argillaceous*; 8 of *mild calcareous earth*, and 25 of *iron*. And Faujas de Saint Fond gives the following proportions, *viz.* 46 of *siliceous*, 30 of *argillaceous*, 10 of *calcareous*; 6 of *magnesian earth*; and 8 of *iron*. The Editor.

SECT.

SECT. 438. (295.)

A. Iceland agat, *Achates Islandicus niger.*

It is black, solid, and of a glassy texture; but in thin pieces; it is greenish and semi-transparent like glass bottles, which contain much iron. The most remarkable is, that such large solid masses are found of it, that there is no possibility of producing the like in any glasshouse.

It is found in Iceland, and in the island of Ascension. The jewellers employ it as an agat, though it is too soft to resist to wear. *See N° 21 of the preceding* note; and p. 473, and p. 923.

SECT. 439. (296.)

B. Rhenish millstone, *Lapis molaris Rhenanus.* Is blackish grey, porous, and perfectly resembles a sort of slag produced by Mount Vesuvius. If I am mistaken in this, I hope that somebody else will describe the constituent parts of this millstone.

SECT. 440. (297).

B. Pumice stone, *Pumex* [e].

It is

[e] The pumice stone, or *Bimstein* of the Germans, is rather a volcanic ejection, than a volcanic production. It is of

It is very porous and bliftered, in confequence of which it is fpecifically very light. It refembles that frothy flag which is produced in our iron furnaces,

1. White.

2. Black,

The colour of the firft is perhaps faded or bleached, becaufe the fecond kind comes in that ftate from the laboratory itfelf, viz, the volcanos,

SECT. 441. (298.)

D. Pearl flag, *Scoriæ conftantes globulis vitreis conglomeratis.*

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of a *white*, *reddifh-brown*, *grey*, or *black* colour. Its confiftence is rough and porous, confifting of flender fibres parallel to each other; is very light, and fo that it fwims on water, and difficultly gives fire with fteel. It feems to have originally been an afbeftos decompofed by the action of fire; but, on obferving the appearance of that glaffy-flag produced in the iron furnaces, which quite refembles the pumice-ftone, and is produced from the calcareous fluxes to help the fufion of the ore, it may rather be attributed to that kind of froth which muft be formed at the top of the fufed matters in the volcanic craters. 100 parts, according to Bergman, contain from 6 to 15 of magnefia, with a fmall proportion of calcareous earth, and the moft part of filex.

Mr. Dolomieu has lately difcovered at *Stromboli* another fort of *pumice*, which feems to be a ferrugineous granite, altered by fire.

The pumice-ftone is commonly employed to rub fmooth and polifh the furface of metals, wood, pafteboard, ftone, and of other matters, as, by the harfh and brittle particles of its fubftance, it carries off the cruft and inequalities of the furface that is wanting to be evened and fmoothed. *The Editor.*

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Is compounded of white and greenifh glafs particles, which feem to have been conglutinated while yet foft, or in fufion. It is found on the ifle of Afcenfion.

SECT. 442. (299.)

E. Slag-fand or afhes. *Scoriæ pulverulentæ, Cineres Vulcanorum.*

This is thrown forth of the volcanos, in form of larger or fmaller grains. It may perhaps be the principle of the Terra Puzzolana (Sect. 342. *a.*), becaufe fuch an earth is faid at this time to cover the ruins of Herculanum near Naples, which, hiftory informs us, was deftroyed by a volcano during an earthquake.

SECT. 443. (300.)

OBSERVATIONS on the preceding SLAGS [*f*].

It feems as if we could not go any farther in the arrangement of bodies belonging to the

[*f*] The fubftances ejected by volcanos are, *phlogifticated*, *fixed*, and *inflammable air*; *water*, *afhes*, *pumice ftones*, *ftones* that have undergone no fufion, and *lavas*. The water proceeds partly from the condenfed vapours, and partly from the combination mentioned at N° 6 of the laft note [*d*], or at leaft from that which has caufed the explofion, as already defcribed in the fame note.

the mineral kingdom, than to the black mould (Sect. 436.) and the slags, as being the extremes.

However, if these slags likewise decay, and in length of time become an earth, which possibly may happen; there is then a new substance beyond them, which however may return back and circulate again in some known form. It is obvious how the old heaps of slags from the iron furnaces decay, and at last produce vegetables, which cannot be ascribed to a black mould alone carried thither by the wind. The same may perhaps happen with the natural slags in the open air; but we do not know if it is so, nor what different forms this and every other earth, which circulates in animals and

If the ashes of the volcano are plentifully moistened with water, they produce that kind of *tufa* or *tophi*, *traas*, and *pori*, all which are nearly of the same kind. Great heaps of *tufa*, or *tophi*, are found in Italy, forming various hills, and covering large tracts of land, from whence it is cut and carried for making the walls, vaults, and upper ceilings of houses; it is a very soft kind of stone, extremely advantageous for these purposes, on account of its small weight, and of being easily cut into any form. The inhabitants of Umbria, and other parts of Italy, dig, with very little labour, various subterraneous, corridores, and large excavations under earth, where they keep wines, and many provisions quite free from the irregularities and excesses of temperature. *See the* notes *to p.* 735.

The lava, according to Kirwan, is the immediate produce of liquefaction, or vitrification, by the volcanic fires; and must be distinguished from their other productions of the same ejected at the same time, having been affected by the water, either in a liquid or fluid state.

All lavas are more or less magnetic; give fire with steel, are generally of a granular texture, and fusible *per se*. Most of and vegetables, further assumes. However, in such circumstances, as their particles become or are already very minute, and most part of the phlogiston becomes volatile, when acted upon by heat or fire, it seems probable, that, by a slow separtion of the phlogiston, or a union by means of salts, this earth is more apt to become a clay, provided it is not by any previous revolution laid in such places as to change it into slate, pit-coal, &c.

If at any time it should happen that a volcano should burst out of a mountain, whose strata we knew before, we could at least imagine some reasons for this wonderful effect. However, the learned would nevertheless, perhaps, want some knowledge about the substances

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of them are decomposable by long expósure to the air, sooner or later, according to the proportion of iron and calcareous earth they contain; and according as they were more or less perfectly melted. By the observations of Sir William Hamilton, the lava of *Vesuvius* forms one or two feet of mould in 1000 years. This bed being afterwards covered with fresh lava from another explosion; and this, after mouldering by those of still later eruptions, affords some ground for calculating the age of the volcano, at least within certain limits. Recupero, a canon of the cathedral of Catania in Sicily, says, that if it be allowed to judge by the number of the lavas found in Mount Etna, disposed in alternate strata with vegetable earth, there must have been the space of 14,000 years to be formed from the deepest to the upper one.

Lavas may be reduced to these 3 varieties, *viz. cellular, compact*, and *vitreous*. The *cellular* underwent only the first and lowest degree of fusion, being just mollified and heated to expell the *fixt air* contained in the argillaceons particles. Hence they abound in small cavities arising from the ſtances of the ſtrata, and the manner of their formation; ſince in this circumſtance water and other obſtacles have hindered people too much from making the due obſervations thereon.

Meanwhile, the more we conſider, on the one part, all the modification and alterations the earths undergo by means of fire and water, by the free or impeded acceſs of the air, by the volatility and attraction of the acid ſalts, whereby are produced ſolution and hardening, compoſition and ſeparation; and, on the other part, reflect on the ſhortneſs of a man's life, perhaps alſo dedicated to other buſineſs, on the difficulty of obſerving the ſubterraneous effects, and

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the expanſion of that air, after it had recovered its elaſtic ſtate; on this account they are often ſo light, as to float for ſome time on water, and have been miſtaken for pumice-ſtones. Their colour is black, grey, brown, or reddiſh brown; and their cavities are even filled with cryſtallizations: of this ſort is the black cellular mill-ſtone of the *Rhine*, mentioned in Sect. 439.

Theſe ſtones contain from 45 to 50 *per cent.* of *ſilex*; from 15 to 20 of *iron*; 4 or 5 of pure *calcareous earth*; and the remainder is *argill.*

The *compact lavas* have undergone a more perfect degree of fuſion; yet they are not entirely deſtitute of cavities, which contain finer cryſtals, or pieces more perfectly vitrified; their colour is black or brown; their fracture is ſtill obſcure and not glaſſy, as the ſtones themſelves are opake. If not cracked, they give a clear ſound when ſtruck. Their conſtituent parts are the ſame as the preceding ones. The uſual fluxes attack them with difficulty; and microcomic ſalt has ſcarcely any power over them.

The *vitreous* lava has been more compleatly melted, and forms vitrifications of different colours, generally black or aſh-and on ſeveral things, which prevent the making diſcoveries, by which we might find out ſome eaſier means to attain true knowledge by judicious experiments; the more we ſhall find what is wanted to form mineral ſyſtems, and for this reaſon be apt to excuſe the faults of thoſe which have been hitherto publiſhed.

From thoſe who of themſelves are ſuſceptible of theſe ſentiments, I ſuffer with pleaſure that judgement, which I am myſelf ready to pronounce upon this Eſſay:

Tranſeat cum cæteris.

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aſh-coloured, rarely blue or greeniſh. According to the analyſis made by Bergman of this lavà, it afforded 49 *per cent.* of *ſilex*, 35 of *argill*, 4 of pure *calcareous earth*, and 12 of *iron*. Another ſpecimen from the Lipari iſlands, afforded 69 of ſilex, 22 of *argill*, and 9 of iron. Theſe lavas melt very difficultly *per ſe*. The *black Agate of Iceland*, deſcribed in Sect. 438, called otherwiſe the *Lapis Obſidianus*, and *Piedra de Gallinaço*, mentioned in Nº 21 of note [*d*] to pag. 916. is of this kind of lava, and has the ſame component parts.

The harder ſort of *pitch ſtone*, which gives fire with ſteel, belongs to this ſpecies. This ſtone is of a greyiſh, greeniſh, black, red, or brown colour; has a glaſſy appearance, of a ſemi-vitrified ſubſtances; and melts eaſily *perſe*. It often contains heterogeneous ſubſtances. Its component parts are 65 *per cent.* of *ſilex*, 16 of *argill*, and 4 of *iron*; the 14 wanting parts were diſſipated in the analyſis made by Wiegleb, as Kirwan aſſerts.

The beds of lava are deepeſt and narroweſt in the proximity of the crater; and broader and ſhallower as they are more diſtant, unleſs ſome valley intervenes; *pumice-ſtone* and *aſhes* lie ſtill more diſtant. From theſe obſervations, ſays Kirwan, extinguiſhed volcanos are traced.

The Baſaltic mountains, which are very common in *Sweden*, ſeem to owe their origin to ſub-marine volcanos. *The Editor.*

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DESCRIPTION

OF A

Mineralogical Pocket-Laboratory;

AND ESPECIALLY THE

USE OF THE BLOW-PIPE

IN

MINERALOGY,

BY GUSTV. VON ENGESTROM,

DESCRIPTION, &c.

§ 1. THAT Science which teaches us the properties of mineral bodies, and by which we learn how to characterize, distinguish, and class them into a proper order, is called *Mineralogy*. This, like all other sciences, when rightly cultivated, and employed to its proper end (the Public Good), furnishes us with many useful discoveries, in proportion as it increases.

§ 2. Though mineralogy has been studied for several ages, yet its progress has been very slow.

Some learned men have, indeed, endeavoured to bring it into some systematical order; But as the passion for only collecting minerals and fossils has still predominated over that of enquiring into the nature of the subjects themselves, they have for the most part met with but very little success. Those who were *mere Collectors*, being superior in number to the *scientific men*, or *true Mineralogists*, and having more opportunities of getting new specimens, were most of them not so communicative to the latter as they ought to have been. Some of these, were wholly taken up in gathering together

together immenſe heaps of things, ſeeming almoſt reſolved to get the whole of Nature into their cabinets, without having regard to any true order; while others, propoſing to correct this inconvenience, would pretend to ſome interior knowledge, as if that had been a conſequence of their collection; and by that fell into a ſtill greater extravagance.

All this certainly hindered mineralogiſts from improving much in the ſcience; but, happily, thoſe times are paſt. The world is grown more reaſonable at preſent, and Mineralogy ſeems to be more and more encouraged.

The great utility of the mineral bodies already known, promiſes us a much greater advantage from the ſtudy of this ſcience, than the mere pleaſure of collecting. But, in order to come at this advantage, we ought to ſearch into the very principles of theſe bodies, that we may be certain of not deceiving ourſelves in our judgement concerning them.

§ 3. As the principal intention of cultivating Mineralogy is to diſcover the œconomical uſe of minerals, it is neceſſary to know every mineral body in regard to all its effects; and thence to determine the beſt uſe it might be put to. A Syſtem of Mineralogy thus founded on the effects of its ſubjects, muſt be more ſcientifical, ſince it always has in view that valuable point, *their application to Common Life.* And ſince it is natural to the human mind to adapt every thing to its own advantage

vantage as far as possible, such a system must be more generally received, and at the same time more easily understood, as it includes the mineral bodies in a less number of classes, orders, &c. by which the memory is not so much loaded, as if only their surfaces had been described.

§ 4. This being granted, let us consider what difficulties are to be met with in examining mineral bodies. These often resemble one another in their external appearances, though their constituent parts are quite different, and consequently make them useful in different ways. Most of them require also to be changed from their natural form, and even often dissolved, before they can be made any use of. Their figure and colour, or, in short, their surfaces, are therefore not solely to be depended upon; we must penetrate into them; and they must be decompounded according to the principles of chemistry.

§ 5. By examining the mineral kingdom in this manner, we may now and then find the subjects of our experiments (even if nearly the same) to differ in some of their effects, which is particularly owing to the difficulty of justly determining the degrees of fire employed; a difficulty not yet removed, but which, however, ought not to hinder us from going as far as possibly we can, since we find in practice, that such obstacles are often remedied by repeated experiments; and of these we never can make too many, if judiciously performed.

§ 6. This

§ 6. This method of ſtudying Mineralogy was adopted a conſiderable time ago: but Mr. Pott, at Berlin, has brought it to a greater perfection: and after him Mr. Cronſtedt, in Sweden, extended it yet farther, ſubmitting every mineral body, that came into his poſſeſſion, to chemical experiments; in conſequence of which he afterwards publiſhed his *Eſſay towards a Syſtem of Mineralogy.*

§ 7. Thus the greateſt obſtacle is removed; the beſt method to learn Mineralogy is laid open, in following which we are enabled to render this Science more and more perfect. To obtain this end, chemical experiments are without doubt neceſſary; but as a great part of the mineral kingdom has already been examined in this manner, we do not want to repeat all thoſe experiments in their whole extent, unleſs ſome new and particular phœnomena ſhould diſcover themſelves in the things we are examining; for otherwiſe the tedious-neſs of thoſe proceſſes might diſcourage ſome from going farther, and take up much of the time of others, that might be better employed. An eaſier way may therefore be made uſe of, which even for the moſt part is ſufficient, and which, though made in miniature, is yet as ſcientifical as the common manner of proceeding in the laboratories; ſince it imitates that, and is founded upon the ſame principles. This conſiſts in *a method of making experiments upon a piece of charcoal with the concentrated flame of a candle urged by air from a Blow-*

pipe

pipe [a]. The heat occaſioned by this is very intenſe: and mineral bodies may be thus burned, calcined, melted, or ſcorified, &c. as well as in any great works.

§ 8. The Blow-pipe is in common uſe among jewellers, goldſmiths, glaſs-blowers, &c. and has even been uſed a little by the chemiſts and mineralogiſts; but, to the beſt of my knowledge, Mr. Cronſtedt is the firſt who made ſuch an improvement in its uſe, as to employ it in examining all mineral bodies. This gentleman invented ſome other apparatus, neceſſary in making the experiments, to go with the Blow-pipe, which all together make a neat little caſe, that, for its facility of being carried in the pocket, particularly on travels, might be called a *Pocket-Laboratory*: and as neither the Pocket Laboratory, nor even the extenſive uſe of the Blow-pipe, is yet generally known, I think it will not be altogether uſeleſs, to give a deſcription of it.

§ 9. The Blow-pipe is repreſented in its true figure and ſize, Plate 1, letter Q. D. The globe *b. b.* is hollow, and made on purpoſe to condenſe the vapours, which are always accumulated in the Blow-pipe when it has been uſed ſome time: if this globe were not there, the

[a] The meaning would be more preciſe and intelligible, if it had been ſaid, that it is a *method of aſſaying, by the concentrated flame of a candle, urged by air from a blow pipe, very ſmall pieces of each diſtinguiſhable component part* of any ore, ſupported upon *a piece of charcoal, or otherwiſe.* The Editor.

vapours would go directly with the wind out into the flame, and would thereby cool the assay.

The hole in the small end *c.* through which the wind comes out, ought not to be larger than the size of the finest wire. This hole may now and then be stopped up with some small obstacle, which checks the force of the wind; one ought therefore to have a piece of the finest wire, to clear it with when required. And, in order to have this wire the better at hand, a small quantity of it may be packed in an inside corner of the case.

§ 10. In order to determine the most convenient proportions of this instrument, several Blow-pipes of different sizes, both bigger and smaller, have been tried: The former have required too much wind, and the latter being too soon filled with the wind, have returned it back again upon the lungs. Both these circumstances greatly impeded the experiments, and are perhaps even prejudicial to health. This size fig. 1, is found to answer best; and though the hole must be as small as before mentioned (Sect. ix.) yet the sides of the pipe at the point must not be thinner, nor the point narrower than here represented, else it will be too weak, and will not give so good a flame. It is also to be observed, that the canal throughout the pipe, but particularly the hole at the small end, must be made very smooth,

ſmooth, ſo that there may be no inequalities in it; as the wind would elſe be divided, and conſequently the flame made double. The Blow-pipe is to be reckoned the beſt, through which the longeſt and moſt pointed flame from off a common-ſized candle can be formed. Theſe Blow-pipes are commonly made of braſs or ſilver. *See the* deſcription *and* uſe *of the* Blow-pipe *in the Appendix to this Treatiſe.*

§ 11. *This Section of the Author in the former Edition, conſiſted of a deſcription of the Articles contained in the* Pocket Laboratory. *But as all theſe articles are contained in the* Laboratory *deſcribed in the Appendix to this Treatiſe, together with others, which the compactneſs of the arrangement, and the experience of Bergman and other late Chemiſts have enabled the Editor to add to them; it was thought unneceſſary to reprint the preſent Section.* The Editor.

§ 12. Whenever any ſubſtance is to be tried, one muſt not begin immediately with the Blow-pipe; but ſome preliminary experiments ought to go before, by which thoſe in the fire may afterwards be directed. For inſtance, a ſtone is not always homogeneous, or of the ſame kind throughout, although it may appear to the eye to be ſo: The magnifying-glaſs is therefore neceſſary, to diſcover the heterogeneous particles, if there be any; and theſe ought to be ſeparated, and every part tried by itſelf, that the effects of two different things, examined together, may not be attributed to one alone. This might happen, with ſome of the finer *micæ*, which are now and then found mixed with ſmall particles of quartz, ſcarcely to be perceived by the eye. The Trapp, (in German *Schwartzſtein*) is alſo ſometimes mixed with very fine particles of Feltſpar (*ſpatum ſcintillans*) or of Calcareous Spar, &c. After this experiment, the hardneſs of the ſtone in queſtion muſt be tried with the ſteel. The Flint and Garnets are commonly known to ſtrike fire with the ſteel; but there are alſo other ſtones, which, though very ſeldom, are found ſo hard as to ſtrike fire.

There is a kind of Trapp of that hardneſs, in which no particles of Feltſpar are to be ſeen. Coloured glaſſes reſemble true gems; but as they are very ſoft in proportion to theſe, they are eaſily diſcovered by the means of the file. The common quartz-cryſtals are harder than coloured glaſſes, but ſofter than the gems. The loadſtone diſcovers the preſence of iron, when it is not mixed in too ſmall a quantity in the ſtone, and often before the ſtone is roaſted. Some kinds of *Hæmatites*, and particularly the *Cæruleſcens*, greatly reſemble ſome other iron ores; but this diſtinguiſhes itſelf from them by a red colour, when pounded, the others giving a blackiſh powder, and ſo forth.

§ 13. To manage the Blow-pipe with eaſe requires ſome practice. A beginner blows generally too ſtrongly, which forces him to take

take breath very often, and then he draws the flame at the ſame time along into the Blow-pipe; this is troubleſome for himſelf, and the matter cools always a little at the ſame time. But more experienced perſons can breathe in through the noſe, and at the ſame time blow through the pipe, ſo as to keep up a conſtant flame from the candle. The whole art conſiſts in this, that while the air is inſpired through the noſtrils, that which is contained in the mouth, be forced out through the tube, by the muſcular compreſſion of the cheeks; ſo that the action of the noſe, lungs, and mouth, reſemble the action of bellows with double partitions. In this manner there is no need of blowing violently, but only with a moderate and equal force, and thus the breath can never fail the operator. The only inconvenience attending it is, that the lips grow weak or tired, after having continued to blow for a conſiderable time; but they ſoon recover their former ſtrength, by ceaſing to blow for ſome minutes [a].

§ 14. The candle uſed for this purpoſe (Sect. 7.) ought to be ſnuffed often, but ſo, that the top of the wick may retain ſome fat in it, becauſe the flame is not hot enough when the wick is almoſt burnt to aſhes; but

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[a] The new form given to the mouth-piece of the improved tube, which has two oppoſite angular foldings on the outſide, fits the lips of the operator ſo well, as to require a very weak preſſure to blow through it. *The Editor.*

only the top muſt be ſnuffed off, becauſe a low wick gives too ſmall a flame. The blue flame is the hotteſt; this ought therefore to be forced out when a great heat is required, and only the point of the flame muſt be directed upon the ſubject which is to be aſſayed *.

§ 15. The piece of charcoal made uſe of in theſe experiments (§ 7.) muſt not be of a diſpoſition to crack. If this ſhould happen, it muſt gradually be heated until it does not crack any more, before any aſſay is made upon it. If this is not attended to, but the aſſay made immediately with a ſtrong flame, ſmall pieces of it will ſplit off in the face and eyes of the aſſayer, and often throw along with them the matter that was to be aſſayed. Charcoal which is too much burnt conſumes too quick during the experiment, leaving ſmall holes in it, wherein the matter to be tried may be loſt: And charcoal that is burnt too little, catches flame from the candle, burning by itſelf like a piece of wood, which likewiſe hinders the proceſs.

§ 16. Of thoſe things that are to be aſſayed, only a ſmall piece muſt be broken off for

* It is moſt cleanly and convenient, that the candle be made of wax, and the wick ſhould be thicker than ordinary. It's upper end muſt be bended (*ſee fig.* 20. *plate* 2.) towards the matter intended to be heated, and the ſtream of air muſt be directed along the ſurface of the bended part, ſo as not abſolutely to touch it, *The Editor.*

that

that purpose, not bigger than that the flame of the candle (§ 7. 14.) may be able to act upon it at once, if required; which is sometimes necessary; for instance, when the matter rquires to be made red hot throughout. A piece of about an eighth part of an inch square is reckoned of a moderate size, and fittest for experiments; seldom more, but rather less. This proportion is only mentioned as a direction in regard to the quantity, the figure being of no consequence at all, a piece broken off from a stone seldom or never happening to be square; but here it is to be observed, that the piece ought to be broke as thin as possible, at least the edges. The advantage of this is easily seen, the fire having then more influence upon the subject, and the experiment being more quickly made. This is particularly necessary to be observed when such stones are to be assayed, which although in some respects fusible by themselves, yet resist the action of the fire considerably; because they may by these means be brought into fusion, at least at their edges, which else would have been very difficult, if the piece had been thick.

§ 17. Some of the mineral bodies are very difficult to be kept steady upon the charcoal during the experiment, before they are made red hot; because, as soon as the flame begins to act upon them, they split asunder with violence, and are dispersed. Such often are those which are of a ſoft conſiſtence, or a particular figure, and which preſerve the ſame figure in however minute particles they are broke; for inſtance, the Calcareous Spar, the Sparry Gypſum, Sparry Fluor, White Sparry Lead-ore, the Potters Ore (*Galena teſſellata*), the Teſſellated Mock-lead or Blende, &c. even all the common fluors which have no determinate figure, and moſt of the *Mineræ metallorum calciformes cryſtalliſatæ* or *ſpatoſæ*. All theſe are not ſo compact as common hard ſtones; and therefore, when the flame is immediately urged upon them, the heat forces itſelf through and into their clefts or pores, and cauſes this violent expanſion and diſperſion. Many of the clays are likewiſe apt to crack in the fire, which may be for the moſt part aſcribed to the humidity, of which they always retain a portion. Beſides theſe enumerated, there may be found now and then other mineral bodies of the ſame nature; but it is, however, not ſo common.

The only way of preventing this inconvenience is, to heat the body as ſlowly as poſſible. It is beſt, firſt of all, to heat that place of the charcoal where the piece is intended to be put on, and afterwards lay it thereon; a little crackling will then enſue, but commonly of no great conſequence. After that, the flame is to be blown very ſlowly towards it, in the beginning not directly upon, but ſomewhat above it, and ſo approaching nearer and nearer with the flame until it becomes

comes red hot. This will do for the moſt part; but there are nevertheleſs ſome, which, notwithſtanding all theſe precautions, it is almoſt impoſſible to keep on the charcoal. Thus the Fluors are generally the moſt difficult; and as one of their principal characters is diſcovered by their effects in the fire *per ſe*, (§ 18. *f.*) they ought neceſſarily to be tried that way. To this purpoſe it is beſt to make a little hole in the charcoal to put the Fluor in, and then to put another piece of charcoal as a covering upon this, leaving only a ſmall opening for the flame to come in at, and to look at the proof. As this ſtone will nevertheleſs ſplit and fly about, a larger piece thereof than is before-mentioned (§ 16.) muſt be taken, in order to have at leaſt ſomething of it left.

But if the experiment is to be made upon a ſtone whoſe effects one does not want to ſee in the fire *per ſe*, but rather with fluxes, then a piece of it ought to be forced down into melted borax, (§ 23.) when always ſome part of it will remain in the borax, notwithſtanding the greateſt part may ſometimes fly away by cracking.

§ 18. As the ſtones undergo great alterations when expoſed to the fire by themſelves, whereby ſome of their characteriſticks, and often the moſt principal, are diſcovered, they ought firſt to be tried that way; obſerving what has been ſaid before, concerning the quantity of matter, direction of the fire, &c.

The

The following effects are generally the results of this experiment, viz.

a. Calcareous earth or ſtone, when it is pure, does not melt by itſelf, but becomes white and friable, ſo as to break freely between the fingers; and, if ſuffered to cool, and then mixed with water, it becomes hot, juſt like common quick-lime. As in theſe experiments only very ſmall pieces are uſed, (§ 16.) this laſt effect is beſt diſcovered by putting the proof on the outſide of the hand, with a drop of water to it, when inſtantly a very quick heat is felt on the ſkin. When the calcareous ſubſtance is mixed with the vitriolic acid, as in gypſum, or with a clay, as in marle, it commonly melts by itſelf; yet more or leſs difficultly in proportion to the differences of the mixtures. Gypſum produces generally a white, and marle a grey glaſs or ſlag. When there is any iron in it, as a white iron ore, it becomes dark, and ſometimes quite black, &c. [*a*].

b. The

[*a*] *Crude calcareous earth* effervesces in a ſmall degree with the alkali of Soda, but is hardly diſſolved. But if it be previouſly burned, it is neither divided nor apparently diminiſhed.

The former is diſſolved in crude borax with effervescence, the latter with the application of the ſame flux, ſcarcely emits any bubbles. The ſame phænomena offer themſelves with the microſcomic ſalt, but the effervescence appears rather greater. It is to be remarked, that the particle of calcareous earth is eaſily diſſolved, either in borax or the phoſphoric acid, and the ſpherules remain entirely pellucid, as mentioned in the note to pag. 18; but if the quantity or proportion *b*. The Siliceæ never melt alone, but become generally more brittle after being burnt. Such of them as are coloured become colourless, and the sooner when it does not arise from any contained metal; for instance, the Topazes, Amethists, &c. some of the precious stones, however, excepted. And such as are mixed with a quantity of iron, grow dark in the fire, as some of the Jaspers, &c.

c. Garnets melt always into a black slag, and sometimes so easily that they may be brought into a round globule upon the charcoal.

d. The Argillaceæ, when pure, never melt, but become white and hard. The same effects follow when they are mixed with phlogiston; for instance, the *Soap-rock* is easily cut with the knife; but, being burnt, it cuts glass, and would strike fire with the steel, if as large a piece as is necessary for that purpose could be tried in this way. The *Soap-rocks* are sometimes

proportion added to the flux be made greater, till at length the flux becomes saturated, and the flame be then removed; that part which was held in solution merely through the heat is separated, which clouds are first formed, and afterwards the globule becomes opake, but may be again rendered transparent by heat. This is perfectly consentaneous to what happens in the *humid way*. For hot water being saturated with nitre or glauber's salt, deposes upon cooling that quantity which it sustained merely by the action of the extraordinary heat. If the melted pellucid globule, which, by refrigeration, would become opake, be quickly immerged in tallow, water, or any other warm fluid (for in cold fluids they often fly in pieces) so that it may harden a moment sooner, it retains its transparency; the particles being as it were ſometimes found of a dark brown and nearly black colour, but become for all that quite white in the fire, like a piece of China ware. However, care muſt be taken not to urge the flame from the top of the wick, there being for the moſt part a ſooty ſmoke, which commonly will darken all that it touches; and if this is not obſerved, a miſtake in the experiment might eaſily happen. But if it is mixed with iron, as it is ſometimes found, it does not ſo eaſily part with its dark colour. The Argillaceæ, when mixed with lime, melt by themſelves, as above-mentioned (*a*). When mixed with iron, as in the Boles, they grow dark or black; and if the iron is not in too great a quantity, they melt alone into a dark ſlag; the ſame happens, when they are mixed with iron

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were fixed in that ſtate in which they form a maſs pervious to the light; a phænomenon which is highly deſerving of attention, and cannot be performed in a crucible.

Ponderous Earth, expoſed alone to the flame, becomes (like calcareous earth) cauſtic, ſoluble in water, and deprived of the faculty of efferveſcing with acids.

In the alkali of ſoda it efferveſces little, but is ſenſibly diminiſhed.

In borax it is diſſolved with a ſlight efferveſcence.

It is likewiſe diſſolved in the microſcomic ſalt, but with an ebullition ſomewhat greater.

The phænomena reſpecting ſaturation, which have been noted in calcareous earth, take place likewiſe in this and other ſubſtances.

Magneſia being ignited like the earths already mentioned, but much more eaſily, it loſes the aerial acid, and therefore produces no bubbles by being afterwards applied to acids. It becomes phoſphoric after calcination, according to M. Macquer and Lavoiſier. But it does not acquire ſolubility in water by this treatment.

In

iron and a little of the vitriolic acid, as in the common clay, &c. [b]. *e.* Mica

In the alkali of soda it effervesces little, and is scarcely at all diminished.

In borax it is dissolved with effervescence.

In the microscomic salt it is likewise dissolved, but with a greater commotion. *Bergman. See* Note [*i*] *to page* 94.

[*b*] *Common clay* abounds with heterogeneous matters, and always contains at least a portion of siliceous earth, the quantity of which is considerable, being commonly more than half the mass; therefore, when it is required to be pure, it is necessary to make use of the earth of allum carefully washed.

Being ignited, it hardens at the same time that its dimensions are contracted. It is capable of acquiring a flinty hardness by means of ignition.

In the alkali of soda it effervesces a little, but is dissolved in a very small quantity.

Borax takes it up with some effervescence.

The microscomic salt shews a more sensible ebullition.

Siliceous Earth. It is not fusible alone. The alkali of soda dissolves it with a vehement effervescence, and affords a pellucid glass, if the weight of the earth in solution exceeds that of the flux. This experiment, and every other in which the alkali is made use of, must be performed in the spoon.

Borax dissolves it but slowly, and without effervescence.

The microscomic salt very slowly, and without the least ebullition, takes up a portion so small, that it hardly seems to affect it.

Derivative Earths, which are infusible alone.

The Diamond (sometimes decrepitating, and always diminishing by a long continued fire), Pure Asbestus †, Siliceous Hydrophanes, Porcelane Clay †, the Hyacinth, Jasper, Pure Mica †, Quartz, the Ruby, the Sapphire, Flint, Steatite †, the Topaz.

N. B. Those substances which are marked thus †, become hard in the fire.

Infusible Earths which change their colour.

Bolar clays in general become black.

Calcareous earth vitiated with manganese, becomes black.

Calcareous earth, rendered black by a subtle bitumen, becomes white.

Some

e. Mica and Abeſtos become ſomewhat hard and brittle in the fire, and are more or leſs refractory, though they give ſome marks of fuſibility.

f. The Fluors diſcover one of their chief characteriſtics by giving a light, like Phoſphorus, in the dark, when they are ſlowly heated; but loſe this property, as well as their colour, as ſoon as they are made red hot. They commonly melt in the fire into a white opaque ſlag, though ſome of them not very eaſily.

g. Some ſorts of the Zeolites melt eaſily and foam in the fire, ſometimes nearly as much as Borax, and become a frothy ſlag, &c.

h. A great many of thoſe mineral bodies which are impregnated with iron, as the Boles, and ſome of the White Iron Ores, &c. as well as ſome of the other iron ores, viz. the Bloodſtone, are not attracted by the loadſtone before they have been thoroughly roaſted, &c.

A further digreſſion upon theſe effects is unneceſſary here, their enumeration belonging more properly to Mineralogy; it is ſufficient only to have mentioned the moſt common, in order the better to explain the experiments that are made with the Blow-pipe.

§ 19. After

Some gems either change their colour or loſe it. Such are the Chryſolite, the Topaz, and ſometimes the Sapphire.

Both the red and green Jaſper become white or greyiſh.

Green, black, and red, ſteatite, become white.

Earths fuſible alone without ebullition,

Aſbeſtus Martialis. Augites, or Aqua Marina †. Baſaltes, Fluor mineralis. Chryſolite †. Granite. Marle. Moſt ſpecimens of the Petroſilex. Ponderous Spar. Spathum pyromachum, or Feld Spar. The Emerald †. Trapp.

N. B.

§ 19. After the mineral bodies have been tried in the fire by themſelves, they ought to be heated with fluxes, to diſcover if they can be melted or not, and ſome other phænomena attending this operation. For this purpoſe three different kinds of ſalts are uſed as fluxes, viz. *Sal Sodæ, Borax, and Sal fuſible microcoſmicum.*

§ 20. The Sal Sodæ is a mineral alcali well known, prepared from the herb Kali or Saltwort; this ſalt is however not much uſed in theſe ſmall experiments, its effects upon the charcoal rendering it, for the moſt part, unfit for it; becauſe, as ſoon as the flame begins to act upon it, it melts inſtantly, and is almoſt wholly abſorbed by the charcoal. When this ſalt is employed to make any experiment, but a very little quantity thereof is wanted at once, viz. about the cubical contents of an eighth part of an inch, more or leſs. This is laid upon the charcoal, and the flame blown on it with the Blow-pipe; but as this ſalt commonly is in form of a powder, it is neceſſary to go on very gently, that the force of the flame may not diſperſe the minute particles of the ſalt. As ſoon as it begins to melt it runs along on the charcoal, almoſt like melted

N. B. Thoſe ſubſtances which are marked thus †, are very difficultly brought to exhibit any ſigns of fuſion.

Earths fuſible with ebullition.

Lithomarga, or Stone-marle. Schoerl. Zeolite. Tourmalin. *The Editor from* Bergman.

tallow,

tallow, and when cold, it is a glaſſy matter of an opaque dull colour ſpread on the coal. The moment it is melted, the matter which is to be tried ought to be put into it, becauſe otherwiſe the greateſt part of the ſalt will be ſoaked into the charcoal, and too little of it left for the intended purpoſe. The flame ought then to be directed on the matter itſelf; and if the ſalt ſpreads too much about, leaving the proof almoſt alone, it may be brought to it again by blowing the flame on its extremities, and directing it towards the ſubject of the experiment. In the aſſays made with this ſalt, it is true, we may find if the mineral bodies which are melted with it have been diſſolved by it or not; but we cannot tell with any certitude whether this is done haſtily and with force, or gently and ſlow; whether only a leſs or a greater part of the matter has been diſſolved; nor can it be well diſtinguiſhed if the matter has imparted any weak tincture to the flag; becauſe this ſalt always bubbles upon the charcoal during the experiment; nor is it clear when cool; ſo that ſcarçely any colour, except it be a very deep one, can be diſcovered, although it may ſometimes be coloured by the matter that has been tried [a].

§ 21.

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[a] *Earths entirely ſoluble in the alkali of Soda with efferveſcence.*

Agate. Calcedony. Carnelian. Turkey Stone † (*Cos Turcica*). Fluor Mineralis †. Onyx. Opal. Quartz. Common Flint. Ponderous Spar.

N. B.

§ 21. The other two ſalts, viz. Borax, and the Sal fuſible microcoſmicum, are very well adapted to theſe experiments, becauſe they may by the flame be brought to a clear uncoloured and tranſparent glaſs; and as they have no attraction to the charcoal, they keep themſelves always upon it in a round globular form. The Sal fuſibile microcoſmicum is very ſcarce, and perhaps not to be met with in the ſhops; it is made of urine: Mr. Margraff has given a full account of its preparation in the Memoirs of the Academy of Sciences at Berlin [b].

N. B. *Thoſe articles which are marked with a* †, *effervesce very little.*

Earths diviſible in the alkali of Soda, with or without effervescence; but not entirely ſoluble.

Amianthus, Asbeſtus. Baſaltes. * Cryſolite †.

(*N. B.* The yellowiſh cryſtalline matter, *which fills up the interſtices of the* native Siberian iron, *exhibits the ſame properties, with reſpect to fire, as the cryſolite*).

Granate †. Hornblende. Jaſper. Marleſtone. Mica. The mineral of alum from Tolfa. Petroſilex. Aluminous ſlate and roof ſlate, from Helſingia. Emeralds. ſteatites. ſpatum pyromachum. Schoerl. Talc. Trapp. Trippel, Turmalin.

N. B. *Thoſe marked* † *do not effervesce.*

Earths neither fuſible nor diviſible in the alkali of Soda.

Diamond. Hyacinth. Ruby. Sapphire. Topaz.

[b] *Earths ſoluble in Borax, with more or leſs effervescence.*

Fluor mineralis †. Marle. Mica †. The mineral of Alum from Tolfa. Aluminous Slate and Roof-ſlate from Helſingia †. Ponderous ſpar. Schoerl. Talc †. Tourmalin.

N. B. *Thoſe marked* † *effervesce very little.*

§ 22. The quantity of these two salts required for an experiment is almost the same as

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Earths soluble in Borax without effervescence.

Agate. Diamond. Amianthus. Asbestus. Basaltes. Calcedony. Cornelian. Chrysolite. Turcica. Granate. Hyacynth †. Jasper. *Lapis ponderosus.* Onyx. Opal. Petro silex. Quartz †. Ruby. Saphire. Common flint †. Steatite Spatum pyromachum. Trapp, Trippel, or Tripoli, Topaz. Zeolite. Silicious Hydrophanes.

N. B. *Those marked † require a larger quantity of the salt, and a longer continuance of fire than the rest.*

Earths soluble in the microscomic salt, with more or less effervescence.

Basaltes †. Turkey Stone ‡. Fluor mineralis †. Marle Mica. The mineral of alum from Tolfa. Schistus aluminaris; schistus tegularis from Helsingia †. Schoerl. Spathum ponderosum. Turmalin †. *Lapis ponderosus.*

N. B. *Those marked † effervesce very little during solution.*

Earths soluble in the microscomic salt, without visible effervescence.

Agate. Diamond. Amianthus. Asbestus. Calcedony. Carnelian. Chrysolite. Granate. Hyacinth. Jasper. Onyx †. Opal. Petrofilex. Quartz †. Ruby. Saphire. common flint †. Emerald. Spathum pyromachum. Talc, Topaz, Trapp, Trippel. Zeolite, Hornblend. Siliceous Hydrophanes. Lithomarga. Steatites

N. B. *Those marked † are more difficultly dissolved than the others.*

Calcareous Earth, ponderous Spar, Gypsum, and other additaments, often assist the solution, as well in the microcosmic salt, as in borax. To which it is necessary to add, that in order to observe the effervescence properly, the matter added to the flux should be in the form of a small particle rather than in fine powder; because in this last there is always air between the particles, which being afterwards driven off by the heat, affords the appearance of a kind of effervescence. *The Editor from* Bergman.

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the Sal Sodæ (§ 20.); but as these salts are crystallised, and consequently include a great deal of water, particularly the borax, their bulk is considerably reduced when melted, and therefore a little more of these may be taken than the before-mentioned quantity.

§ 23. Both these salts, (§ 21.) when exposed to the flame of the Blow pipe, bubble very much and foam before they melt to a clear glass, but more especially the borax, which for the most part depends on the water they contain. And as this would hinder the assayer from making due observations on the phænomena of the experiment, the salt which is to be used must first be brought to a clear glass (§ 21.) before it can serve as a flux; it must therefore be kept in the fire until it is become so transparent that the cracks in the charcoal may be seen through it. This done, whatsoever is to be tried, is put to it, and the fire continued.

§ 24. Here it is to be observed, that for the assays made with any of these two fluxes (§ 22.) on mineral bodies, no larger pieces of these must be taken, than that altogether they may keep a globular form upon the charcoal; because it may then be better distinguished in what manner the flux acts upon the matter during the experiment. If this is not observed, the flux, communicating itself with every point of the surface of the mineral body, spreads all over it, and keeps the form of this last, which commonly is flat, (§ 16.) and by that means hinders the operator obſerving all the phænomena which may happen. Beſides, the flux being in too ſmall a quantity, in proportion to the body to be tried, is too weak to act with all its force upon it. The beſt proportion, therefore, is about a third part of the mineral body to the flux; and, as the quantity of the flux mentioned in § 20. 22. makes a globe of a due ſize, in regard to the greateſt heat that is poſſible to procure in theſe experiments; the ſize the mineral body propoſed in § 16. requires when it is to be tried in the fire by itſelf is too large on this occaſion, the third part of it being here almoſt ſufficient.

§ 25. The Sal Sodæ, as has been ſaid before, is not of much uſe in theſe experiments: nor has it any particular qualities in preference to the two laſt mentioned ſalts, except that it diſſolves the Zeolites eaſier than the Borax and the Sal fuſibile microcoſmicum.

This laſt mentioned ſalt ſhews almoſt the ſame effects in the fire as the borax, and differs from this in very few circumſtances, of which one of the moſt principal is, that, when melted with manganeſe, it becomes of a crimſon hue, inſtead of a jacinth colour, which borax takes.

This ſalt is, however, for its ſcarcity, ſtill very little in uſe, borax alone being that which is commonly uſed. Whenever a mineral body is melted with any of theſe two laſt mentioned ſalts, in the above deſcribed manner (§ 22. et *et ſeq.*) it is eaſily ſeen whether it is quickly diſſolved, becauſe in that caſe an effervefcence ariſes, which laſts till the whole is diſſoved; or whether this is ſlowly done, in which caſe few and ſmall bubbles only riſe from the matter. Likewiſe, if it cannot be diſſolved at all, becauſe then it is obſerved only to turn round in the flux, without the leaſt bubble, and the edges look as ſharp as they were before.

§ 26. In order further to illuſtrate what has been ſaid about theſe experiments, I will mention ſome inſtances out of the Mineralogy, concerning the effects of borax upon the mineral bodies, viz.

a. The calcareous ſubſtances, and all thoſe ſtones which contain any thing of lime in their compoſition, diſſolve readily and with effervefcence in the borax. The effervefcence is the more violent, the greater the portion of lime contained in the ſtone. This reaſon, however, is not the only one in the gypſum, becauſe both the conſtituents of this do readily mix with the borax, and therefore a greater effervefcence ariſes in melting gypſum with the borax, than lime alone.

b. The Siliceæ do not diſſolve, unleſs ſome few, which contain a quantity of iron.

c. The Argillaceæ, when pure, are not acted upon by the borax; but when they are mixed with ſome heterogeneous bodies, they are diſſolved though very ſlowly; ſuch is for inſtance the *Stone Marrow*, the *Common Clay*, &c.

d. The Granateæ, Zeolites, and Trapp, dissolve but slowly.

e. The Fluores, Asbestinæ, and Micaceæ, dissolve for the most part very easily, and so forth.

§ 27. Some of these bodies melt to a colourless transparent glass with the borax; for instance, the *Calcareous* Substances, when pure, the *Fluores*, some of the *Zeolites*, &c. Others tinge the borax with a green transparent colour; viz. the *Granateæ*, *Trapp*; some of the *Argillaceæ*, some of the *Micaceæ* and *Asbestinæ*. This green has its original, partly from a small portion of iron, which the *Granateæ* particularly contain, and partly from phlogiston.

§ 28. The borax cannot dissolve but a certain quantity of a mineral body proportional to its own. Of the calcareous kind it dissolves a vast quantity, but turns at last, when too much has been added, from a clear transparent, to a white, opaque slag. When the quantity of the calcareous matter exceeds but little in proportion, the glass looks very clear as long as it remains hot; but as soon as it begins to cool, a white half opaque cloud is seen to arise from the bottom, which spreads over the third, half, or more of the glass globe, in proportion to the quantity of calcareous matter; but the glass or slag is nevertheless shining, and of a glassy texture when broke; if more of this matter be added, the cloud rises quicker and is more opaque, and

so

ſo by degrees till the ſlag becomes quite milk white. It is then no more of a ſhining, but rather dry appearance, on the ſurface; is very brittle, and of a grained texture, when broke.

§ 29. All that has been ſaid hitherto of experiments upon mineral bodies, relates only to the ſtones and earths. I am now proceeding to the metals and ores, in order to deſcribe the manner of examining theſe bodies, and particularly the management of the Blow-pipe, in theſe experiments. An exact knowledge and nice proceeding are ſo much the more neceſſary here, as the metals are often ſo diſguiſed in their ores, as to be very difficultly known by their external appearance, and liable ſometimes to be miſtaken one for the other: Some of the cobalt ores for inſtance, reſemble much the Pyrites Arſenicalis; there are alſo ſome iron and lead ores, which are nearly like one another, &c.

§ 30. As the ores generally conſiſt of metals mineraliſed with ſulphur or arſenic, or ſometimes both together; they ought firſt to be expoſed to the fire by themſelves, in order, not only to determine with which of theſe they are mineraliſed, but alſo to ſet them free from thoſe volatile mineraliſing bodies: Thus this ſerves inſtead of calcination, by which they are prepared for further aſſays.

§ 31. Here it muſt be obſerved, that, whenever any metal, or fuſible ore, is to be tried, a little concavity muſt be made in that place of the charcoal where the matter is to be put; becauſe, as ſoon as it is melted, it forms itſelf into a globular figure, and might then roll from the charcoal, if its ſurface was plain; but when borax is put to it, this inconveniency is not ſo much to be feared.

§ 32. Whenever an ore is to be tried, a ſmall bit is broke off for that purpoſe, of ſuch a ſize as is directed in § 16: this bit is laid upon the charcoal, and the flame blown on it ſlowly. Then the ſulphur or arſenic begins to part from it in form of ſmoke; theſe are eaſily diſtinguiſhed from one another by their ſmell, that of ſulphur being ſufficiently known, and the arſenic ſmelling like garlick. The flame ought to be blown very gently as long as any ſmoke is ſeen to part from the ore, but, after that, the heat muſt be augmented by degrees, in order to make the calcination as perfect as poſſible. If the heat is applied very ſtrongly from the beginning upon an ore that contains much ſulphur or arſenic, the ore will preſently melt, and yet loſe very little of its mineraliſing bodies, by that means rendering the calcination very imperfect. It is however, impoſſible to calcine the ores in this manner to the utmoſt perfection, which is eaſily ſeen in the following inſtance, viz. in melting down a calcined Potter's ore with borax, it will be found to bubble upon the coal, which depends on the ſulphur which is ſtill left, the vitriolic acid of this uniting with the borax, and

and cauſing this motion. However, lead in its metallic form, melted in this manner, bubbles alone upon the charcoal, if any ſulphur remains in it. But, as the lead, as well as ſome of the other metals, may raiſe bubbles upon the charcoal, although they are quite free from the ſulphur, only by the flames being forced too violently on it, theſe phænomena ought not to be confounded with each other.

§ 33. The ores being thus calcined, the metals contained in them may be diſcovered, either by being melted alone, or with fluxes: when they ſhew themſelves, either in their pure metallic ſtate, or by tinging the ſlag with colour peculiar to each of them. In theſe experiments it is not to be expected that the quantity of metal contained in the ore ſhould be exactly determined; this muſt be done in larger laboratories. This cannot, however, be looked upon as any defect, ſince it is ſufficient for a mineralogiſt, only to find out what ſort of metal is contained in the ore. There is another circumſtance, which, I am ſorry to ſay, is a more real defect in our little laboratory, which is, that ſome ores are not at all able to be tried by it, in ſo ſmall an apparatus: for inſtance, the gold ore called *Pyrites aureus,* which conſiſts of gold, iron, and ſulphur. The greateſt quantity of gold, which this ore contains, is about one ounce, or one ounce and an half out of one hundred pounds of the ore, the reſt being iron and ſulphur; and

and as only a very ſmall bit is allowed for theſe experiments, (§ 16. 31.) the gold contained therein can hardly be diſcerned by the eye, even if it could be extracted; but it goes along with the iron in the ſlag, this laſt metal being in ſo large a quantity in proportion to the other, and both of them having an attraction for each other.

All the Blendes and Black jacks, which are mineral zink ores, containing zink, ſulphur, and iron, cannot be tried this way, becauſe they cannot be perfectly calcined; and beſides, the zink flies off, when the iron ſcorifies: neither can all thoſe Blendes, which contain ſilver or gold mineraliſed with them, be tried in this manner, which is particularly owing to the imperfect calcination; nor are the quickſilver ores fit for theſe experiments, the volatility of this ſemi-metal making it impoſſible to bring it out of the poorer ſort of ores *; and the rich ores, which ſweat out the quickſilver when kept cloſe in the hand, not wanting any of theſe aſſays, &c. Thoſe ores ought to be aſſayed in larger quantities, and even with ſuch other methods as cannot be applied upon a piece of charcoal.

§ 34. Some of the rich ſilver ores are eaſily tried: for inſtance, *Minera argenti vitrea*, commonly

* A piece of gold being laid over the proof, to receive the fumes, readily diſcovers if it contains any quick-ſilver. And it is probable, that by ſimilar proceſſes we may alſo be enabled to diſcover with the Blow-pipe other of the volatile ſubſtances.

commonly called Silver-glafs, which confifts only of filver and fulphur. When this ore is expofed to the flame, it melts inftantly, and the fulphur goes away in fume, leaving the filver pure upon the charcoal, in a globular form. If this filver fhould happen to be of a dirty appearance, which often is the cafe, then it muft be melted anew with a very little borax, and after it has been kept in fufion for a minute or two, fo as to be perfectly melted and red-hot, the proof is fuffered to cool: it may then be taken off the coal: and being laid upon the fteel-plate, (*Pl.* 1. *fig.* N.) the filver is feparated from the flag by one or two ftrokes of the hammer (*Pl.* 1. *fig.* E.). Here the ufe of the brafs ring (*Pl.* 1. *fig.* H.) is manifeft, for this ought firft to be placed upon the plate, to hinder the proof from flying off by the violence of the ftroke, which otherwife would happen. The filver is then found inclofed in the flag of a globular form, and quite fhining, as if it was polifhed. When a large quantity of filver is contained in a lead ore, viz. in a potter's ore, it can likewife be difcovered through the ufe of the blow-pipe, of which more will be mentioned hereafter. (§. 39.)

§ 35. Tin may be melted out of the pure tin ores, in its metalllic ftate. Some of thefe ores melt very eafily, and yield their metal in quantity, if only expofed to the fire by themfelves: but others are more refractory; and as thefe melt very flowly, the tin, which

fweats

ſweats out in form of very ſmall globules, is inſtantly burnt to aſhes, before theſe globules have time to unite, in order to compoſe a larger globe, which, might be ſeen by the eye, is not ſo ſoon deſtroyed by the fire; it is therefore neceſſary to add a little borax to theſe from the beginning, and then to blow the flame violently at the proof. The borax does here preſerve the metal from being too ſoon calcined, and even contributes to the readier collecting of the ſmall metallic particles, which ſoon are ſeen to form themſelves into a globule of metallic tin at the bottom of the whole maſs, neareſt to the charcoal. As ſoon as ſo much of the metallic tin is produced, as is ſufficient to convince the operator of its preſence, the fire ought to be diſcontinued, though the whole of the ore is not yet melted; becauſe the whole of this kind of ore can be ſeldom or never reduced into metal by means of theſe experiments, a great proportion being always calcined: and if the fire is continued too long, perhaps even the metal already reduced may likewiſe be burnt to aſhes; for the tin is very ſoon deſtroyed from its metallic ſtate by the fire.

§ 36. Moſt part of the lead ores may be reduced to a metallic ſtate upon the charcoal. The *Mineræ Plumbi calciformes*, which are pure, are eaſily melted into lead; but ſuch of them, as are mixed with an *ochra ferri*, or any kind of earth, as Clay, Lime, &c. yield very little of lead, and even nothing at all, if the heterogenea

genea are combined in any large quantity: this happens even with the *Minera plumbi calciformis arſenico mixta*. Theſe, therefore, are not to be tried but in larger laboratories. However, every mineral body ſuſpected to contain any metallic ſubſtance may be tried by the blow-pipe, ſo as to give ſufficient proofs whether it contain any or not, by its effects being different from thoſe of the ſtones or earths, &c.

§ 37. The *Mineræ plumbi mineraliſatæ* leave the lead in a metallic form, if not too large a quantity of iron is mixed with it. For example, when a teſſellated or ſteel-grained lead ore is expoſed to the flame, its ſulphur, and even the arſenic, if there be any, begins to fume, and the ore itſelf immediately to melt into a globular form; the reſt of the ſulphur continues then to fly off, if the flame is blown ſlowly upon the maſs; but, on the contrary, very little of the ſulphur will go off, if the flame is forced violently on it: in this caſe, it rather happens that the lead itſelf crackles and diſſipates, throwing about very minute metallic particles. The ſulphur being driven out as much as poſſible, which is known by finding no ſulphureous vapour in ſmelling at the proof, the whole is ſuffered to cool, and then a globule of metallic lead will be left upon the coal. If any iron is contained in the lead ore, the lead, which is melted out of it, is not of a metallic ſhining, but rather of a black and uneven ſurface: a little borax muſt in

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this case be melted with it, and as soon as no bubble is seen to rise any longer from the metal into the borax, the fire must be discontinued: when the mass is grown cold, the iron will be found scorified with the borax, and the lead left pure, and of a shining colour.

§ 38. Borax does not scorify the lead in these small experiments, when it is pure: if the flame is forced with a violence on it, a bubbling will ensue, resembling that which is observed when borax dissolves a body melted with it; but, when the fire ceases, the flag will be perfectly clear and transparent, and a quantity of very minute particles of lead will be seen spread about the borax, which have been torn off from the mass during the bubbling.

§39. If such a lead ore (§ 37.) is rich in silver, this last metal may likewise be discovered by this experiment; because, as the lead is volatile, it may be forced off, and the silver remain. To effect this, the lead, which is melted out of the ore, must be kept in constant fusion with a slow heat, that it may be consumed. This end will be sooner obtained, and the lead part quicker, if, during the fusion, the wind through the blow-pipe is directed immediately, though not forcibly, upon the melted mass itself, until it begins to cool, at which time the fire must be directed on it again. The lead, which is already in a volatilising state, will by this artifice be driven out in form of a subtil smoke; and by thus continuing by turns to melt,

melt the mafs, and then to blow off the lead, as has been faid, until no fmoke is any longer perceived, the filver will at laft be obtained pure. The fame obfervation holds good here alfo, which was made about the gold, that, as none but very little bits of ores can be employed in thefe experiments, it will be difficult to extract the filver out of a poor ore; for fome part of it will fly off with the lead, and, what might be left, is too little to be difcerned by the eye. The filver, which, by this means is obtained, is eafily diftinguifhed from lead by the following external marks, viz. that it muft be red-hot before it can be melted: it cools fooner than lead: it has a filver colour; that is to fay, brighter and whiter than lead: and is harder under the hammer. (§ 34.)

§ 40. The *Mineræ cupri calciformes* (at leaft fome of them) when not mixed with too much ftone or earth, are eafily reduced to copper with any flux; if the copper is found not to have its natural bright colour, it muft be melted with a little borax which purifies it. Some of thefe ores do not at all difcover their metal, if not immediately melted with borax; the heterogenea, contained in them, hindering the fufion, before thefe are fcorified by the flux.

§ 41. The grey Copper ores, which only confift of copper and fulphur, are tried almoft in the fame manner as above mentioned. (§ 40.) Being expofed to the flame by themfelves, they will be found inftantly to melt, and part of their ſulphur to go off. The copper may afterwards be obtained in two ways; the one, by keeping the proof in fuſion for about a minute, and afterwards ſuffering it to cool; when it will be found to have a dark and uneven appearance externally, but which, after being broke, diſcovers the metallic copper of a globular form in its centre, ſurrounded with a regulus, which ſtill contains ſome ſulphur and a portion of the metal: the other, by being melted with borax, which laſt way ſometimes makes the metal appear ſooner.

§ 42. The *Mineræ cupri pyritaceæ*, containing copper, ſulphur, and iron, may be tried with the blow-pipe, if they are not too poor. In theſe experiments the ore ought to be calcined, and, after that, the iron ſcorified. For this purpoſe a bit of the ore muſt be expoſed to a ſlow flame, that as much of the ſulphur as poſſible may part from it before it is melted, becauſe the ore commonly melts very ſoon, and then the ſulphur is more difficultly driven off. After being melted, it muſt be kept in fuſion with a ſtrong fire for about a minute, that a great part of the iron may be calcined; and, after that, ſome borax muſt be added, which ſcorifies the iron, and turns with it to a black ſlag. If the ore is very rich, metallic copper will be had in the ſlag, after the ſcorification: if the ore is of a moderate richneſs, the copper will ſtill retain a little ſulphur, and ſometimes iron: the product will therefore be brittle, and muſt with great cau-

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tion be ſeparated from the ſlag, that it may not break into pieces: and if this product is afterwards treated in the ſame manner as before ſaid, in ſpeaking of the grey copper-ores (§ 41.), the metal will ſoon be produced. But, if the ore is poor, the product after the firſt ſcorification muſt be brought into fuſion, and afterwards melted with ſome freſh borax, in order to calcine and ſcorify the remaining portion of iron; after which it may be treated as mentioned in Sect 41. The copper will, in this laſt caſe, be found in a very ſmall globule.

§ 43. The copper is not very eaſily ſcorified with this apparatus, when it is melted together with borax; unleſs it has firſt been expoſed to the fire by itſelf for a while, in order to be calcined. When only a little of this metal is diſſolved, it inſtantly tinges the ſlag of a reddiſh brown colour, and moſtly opaque; but as ſoon as this ſlag is kept in fuſion for a little while, it becomes quite green and tranſparent: and thus the preſence of the copper may be diſcovered by the colour, when it is concealed in heterogeneous bodies, ſo as not to be diſcovered by any other experiment.

§ 44. If metallic copper is melted with borax by a ſlow fire, and only for a very little time, the glaſs, or ſlag, becomes of a fine tranſparent blue or violet colour, inclining more or leſs to the green; but this colour is not properly owing to the copper, but it may rather be to its phlogiſton; becauſe the ſame colour is to be had in the ſame manner from iron: and theſe glaſſes, which are coloured with either of theſe two metals, ſoon loſe their colour, if expoſed to a ſtrong fire, in which they are made quite clear, and colourleſs. Beſides, if this glaſs, tinged blue with the copper, is again melted with more of this metal, it becomes of a good green colour, which for a long time keeps unchanged in the fire.

§ 45. The iron ores, when pure, can never be melted by themſelves, through the means of the blow-pipe alone, nor do they yield their metal, when melted with fluxes, becauſe they require too ſtrong a heat to be brought into fuſion; and, as both the ore and the metal itſelf very ſoon loſe the phlogiſton in the fire, and cannot be ſupplied with a ſufficient quantity from the charcoal, ſo likewiſe they are very ſoon calcined in the fire. This eaſy calcination is alſo the reaſon why the fluxes, for inſtance borax, readily ſcorify this ore, and even the metal itſelf. The iron loſes its phlogiſton in the fire ſooner than the copper, and is therefore eaſier ſcorified; and this is the principle on which the experiment mentioned in Sect. 42 is founded.

§ 46. The iron is, however, diſcovered without much difficulty, although it were mixed but in a very ſmall quantity with heterogeneous bodies. The ore, or thoſe bodies which

which contain any large quantity of the metal, are all attracted by the loadſtone, ſome without any previous calcination, and others without having being roaſted. When a clay is mixed with a little iron, it commonly melts by itſelf in the fire; but, if this metal is contained in a limeſtone, it does not promote the fuſion, but gives the ſtone a dark, and ſometimes a deep black colour, which always is the character of iron. A *Minera ferri calciformis pura cryſtalliſata*, is commonly of a red colour: This being expoſed to the flame, becomes quite black, and is then readily attracted by the loadſtone, which it was not before. Beſides theſe ſigns, the iron diſcovers itſelf, by tinging the ſlag of a green tranſparent colour, inclining to brown, when only a little of the metal is ſcorified; but as ſoon as any larger quantity thereof is diſſolved in the ſlag, this becomes firſt a blackiſh brown, and afterwards quite black and opaque.

§ 47. Biſmuth is known by its communicating a yellowiſh brown colour to borax: and arſenic by its volatility, and garlick ſmell. Antimony both in form of regulus and ore, is wholly volatile in the fire, when it is not mixed with any other metal (except arſenic), and is known by its particular ſmell; eaſier to be diſtinguiſhed, when once known, than deſcribed. When the ore of antimony is melted upon the charcoal, it bubbles conſtantly, during its volatiliſing.

§ 48. Zinc ores are not eaſily tried upon the coal (Sect. xxxiii.). But the regulus of zinc, expoſed to the fire upon the charcoal, burns with a beautiful blue flame, and forms itſelf almoſt inſtantly into white flowers, which are the common flowers of zinc.

§ 49. Cobalt is particularly remarkable for giving to the glaſs a blue colour, which is the zaffre or ſmalt. To produce this, a piece of cobalt ore muſt be calcined in the fire (Sect. 30. 31.) and afterwards melted with borax. As ſoon as the glaſs, during the fuſion, from being clear, ſeems to grow opaque, it is a ſign, that it is already tinged a little; the fire is then to be diſcontinued, and the operator muſt take hold with the nippers (Pl. 1. *fig.* R.) of a little of the glaſs, whilſt yet hot, and draw it out ſlowly in the beginning, but afterwards very quick, before it cools, whereby a thread of the coloured glaſs is procured, more or leſs thick, wherein the colour may eaſier be ſeen againſt the day or candle-light, than if it was left in a globular form. This thread melts eaſily, if only put in the flame of the candle, without the help of the blow-pipe.

If this glaſs is melted again with more of the cobalt, and kept in fuſion for a while, the colour becomes very deep; and thus the colour may be altered at pleaſure.

§ 50. When the cobalt ore is pure, or at leaſt contains but little iron, a cobalt regulus is almoſt inſtantly produced in the borax, dur-

ing

ing the fusion; but when it is mixed with a quantity of iron, this last metal ought first to be separated, which is easily performed, since it scorifies sooner than the cobalt; therefore, as long as the slag retains any brown or black colour Sect 49. it must be separated, and melted again with fresh borax, until it shews the blue colour.

§ 51. Nickel is very seldom to be had, and as its ores are seldom free from mixtures of other metals, it is very difficultly tried with the blow-pipe. However, when this semi-metal is mixed with iron and cobalt, it is easily freed from these heterogeneous metals, and reduced to a pure nickel regulus by means of scorification with borax, in the same manner as is mentioned Sect I. because both the iron and cobalt sooner scorify than the nickel. The regulus of nickel itself is of a green colour, when calcined: it requires a pretty strong fire before it melts, and tinges the borax with a hyacinth colour. Manganese gives the same colour to borax, but its other qualities are quite different, so as not to be confounded with the nickel [a],

§ 52.

[a] *The habitudes of mineralized metals in the fire.* When metals are dissolved in a natural menstruum, especially sulphur, I call them mineralized. I am aware that many use the term mineralization in a very extended sense, so that they apply it not only to those conjunctions of metals especially, of which arsenic is a part, but even to the mechanical implication of earths or stones. But if arsenic be reckoned a

 mineralizing

§ 52. Thus I have briefly described the use of the Blow-pipe, and the method of employing

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mineralizing substance, it is obvious that we must, as a consequence, allow of no native metals. For each of these are debased with some other metal. Gold, for example, with silver or copper, platina with iron, silver with gold or copper, and so of the rest. If therefore metals can be mineralized by arsenic, why not by other metals?

Sulphurated metals may be freed from their sulphur by a slight roasting upon the charcoal, or at least the greatest part may be driven off. The mineral must not be fused, for the surface in that case becoming much less, the mineralizing matter is much longer in flying off.

The several volatile matters are known by their smell, fume, or cloudy tinge around them; and the fixed residues being fused by the help of the fluxes, their contents may be known partly by their colour, partly by the reduced particles, and lastly by the precipitation they afford upon iron.

Mineralized Gold. Gold cannot be directly united with sulphur; but they are found together in the form of golden pyrites by the mediation of iron, which is strongly attractive of both. But this mineral contains the gold in so small a quantity, that though it may be separated by fusion and scorification, yet as it scarcely exceeds $\frac{1}{1000}$ part of the weight of the particle examined by the blow-pipe, it may easily escape observation by being enveloped in the scoria.

Mineralized Silver. Sulphurated silver, or the vitreous silver ore, being fused on the charcoal, becomes deprived of its mineralizing matter without difficulty; so that a bright globule is often produced, which may be purified, if necessary, with borax. Copper, iron, or manganese, deprive silver of its sulphur.

If arsenic be present, together with sulphur, as in the red ore of silver, both may be driven off by a slight roasting, and the regulus must then be entirely freed from heterogeneous matters by the help of borax.

A mixture of copper, sulphur, arsenic, and silver, or the white silver ore, exhibits a globule, which is rendered impure by these metals.

Silver,

ploying it in the ſtudy of Mineralogy. Any gentleman, who is a lover of this ſcience, will,

Silver, loaded with ſulphur and lead (galena), loſes its ſulphur by roaſting, after which the lead may be gradually deſtroyed by repeated fuſions and coolings, or it may be ſeparated in the cupel.

Mineralized Lead. Galena affords a diſtinct regulus on the charcoal, unleſs it be too much loaded with iron. The lead is precipitated by iron and copper.

Mineralized Copper. This mineral, which is termed the *cinereous*, or more improperly *the vitreous* ore of copper, being gently roaſted with care, and at laſt fuſed, exhibits a maſs, whoſe exterior cruſt is uſually contaminated with ſulphur, but whoſe interior part is pure copper, if the fuſion has been ſufficiently made. The roaſted maſs in general affords the regulus more ſpeedily by the addition of borax. Cupreous pyrites always abounds with iron: this, after a proper roaſting, being ſufficiently fuſed, affords a regulus of copper, if the ore be rich; but if poorer it requires frequent ſcorifications with borax. But if the maſs be fuſed together with borax upon iron, veſtiges of copper are precipitated, though very ſmall. The celebrated Gahn has diſcovered, that if the flame be thrown ſuddenly and by intervals, on a calcined grain of copper ore, the metallic ſplendor appears on its ſurface at thoſe inſtants, which at other times is black.

Mineralized Iron. Sulphurated iron, commonly known by the name of pyrites, may be melted into a globule, which, at the beginning, is environed with a bluiſh flame. But becauſe the metal itſelf is eaſily deprived of its phlogiſton and ſcorified, it exhibits no regulus, either alone, or when treated with borax.

Mineralized Biſmuth. Biſmuth exhibits a blue flame when fuſed.

This ore of biſmuth fuſed with borax is diſtinctly precipitated by iron or manganeſe.

Mineralized Nickel. Sulphurated Nickel has not yet been found, without an addition of iron and arſenic. By roaſting and frequent fuſions with borax, the regulus is obtained, but ſcarcely, if ever, free from foreign matter.

will, by attending to the rules here laid down, be able in any easy manner to amuse himself in discovering the properties of those works of nature which the mineral kingdom furnishes us with. The husbandman may by its help find out what sorts of stones, earths, ores,

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Mineralized Cobalt. What we have said of Nickel is likewise true of sulphurated cobalt. At least it is never without iron, and seldom free from arsenic. The regulus may be obtained upon the charcoal, by the method just mentioned, but always vitiated by heterogeneous matters.

Mineralized Zinc. Though Zink refuses any direct union with sulphur, yet they are found joined in the same mineral, and that especially by the mediation of iron. The mineral, which is called *Blende*, is without metallic splendor, melts by itself upon the coal, commonly tinging the flame after the manner of zink. It is dissolved both in borax and the phosphoric salt. That mineral of zinck, which possesses the metallic splendor has the same properties, but seems to melt or be dissolved more easily. Both these leave a cloudiness upon the charcoal.

Mercury, Arsenic, and Antimony. Mercury, arsenic, and antimony, are volatile in the state of mineralization. The first is found in the form of cinnabar, which melts on the charcoal, exhibits a blue flame, and gradually exhales without having any residue.

Yellow Arsenic, exposed to the exterior flame in such a manner that it may neither melt nor fume, becomes red, but returns to its original yellowness when cool: if it be urged so as just to begin to melt, it acquires a redness which persists even when cold; if a stronger fire be applied, it flies entirely away. Risigal contains a somewhat greater portion of sulphur, and therefore more easily melts, but it flies away totally like the other.

Crude Antimony upon the charcoal melts, fumes, is imbibed, and at last totally vanishes, except a cloudiness about the spot it rested on.

Platina and *Tin* are scarcely found sulphurated in the bowels of the earth. *The Editor from* Bergman.

&c,

&c. there are on his eſtate, and to what œconomical uſes they may be employed. The Scientific Mineraliſt may, by examining into the properties and effects of the mineral bodies, diſcover the natural relation theſe bodies ſtand in to each other, and thereby furniſh himſelf with materials for eſtabliſhing a Mineral Syſtem, founded on ſuch principles as Nature herſelf has laid down in them; and this in his own ſtudy, without being forced to have recourſe to great laboratories, crucibles, furnaces, &c. which is attended with much trouble, and is the reaſon why ſo few can have an opportunity of gratifying their deſire of knowledge in this part of natural hiſtory. I ſhall now add ſome hints towards the improvements of this apparatus, leaving to the judicious practitioner the taſk of completing them.

§ 53. A great number of fluxes might, perhaps, be found out, whoſe effects on mineral bodies might be different from thoſe already in uſe, whereby more diſtinct characters of thoſe mineral bodies might be diſcovered, which now either ſhew ambiguous ones, or which it is almoſt impoſſible to try exactly with the Blow-pipe. Inſtead of the *ſal ſodæ*, ſome other ſalt might be diſcovered better adapted to theſe experiments. But it is very neceſſary not to make uſe of any other fluxes on the charcoal than ſuch as have no attraction to it: if they, at the ſame time, are clear and tranſparent, when melted, as the borax and the *sal fusibile microcosmicum*, it is still better: however, the transparency and opacity are of no great consequence, if a substance is essayed only in order to discover its fusibility, without any attention to its colour; in which case, some metallic slag, perhaps, might be useful.

§ 54. When such ores are to be reduced whose metals are very easily calcined, such as tin, zinc, &c. it might perhaps be of service to add some phlogiston, since the charcoal cannot afford enough of it in the open fire of these essays: such a phlogiston might be hard resin, or some such body. The manner of melting the volatile metals out of their ores *per descensum* might also, perhaps, be imitated: for instance, a hole might be made in the charcoal, wide above, and very narrow at the bottom; a little piece of the ore being then laid at the upper end of the hole, and covered with some very small pieces of the charcoal, the flame must be directed on the top: the metal might, perhaps, by this method, run into the hole below, concealed from the violence of the fire, particularly if the ore is very fusible, &c.

Several of my experiments have indeed induced me to believe the possibility of these improvements; but as I have not yet had an opportunity of bringing them to perfection, I will not deliver them as infallible: these hints are only communicated as an inducement to farther trials.

§ 55.

§ 55. The use of the Pocket Laboratory, as here described, is chiefly calculated for a travelling mineralist. But a person, who always resides at one and the same place, may by some alteration make it more commodious to himself, and avoid the trouble of blowing with the mouth. For this purpose he may have the Blow-pipe go through a hole in a table, and fixed underneath to a small pair of bellows with double bottoms, such as some of the glass-blowers use, and then nothing more is required, than to move the bellows with the feet during the experiment; but in this case a lamp may be used instead of a candle. This method would be attended with a still greater advantage, if there were many such parts as *c c* fig. Q. *Pl.* 1. the opening of which were of different dimensions: those parts might by means of a screw be fastened to the main body of the Blow-pipe, and taken away at pleasure. The advantage of having these nozzles, if I may be permitted to call them so, of different capacities at their ends, would be that of exciting a stronger or weaker heat as occasion might require. It would only be necessary to observe, that in proportion as the opening of the pipe (nozzle) is enlarged, the quantity of the flame must be augmented by a thicker wick in the lamp, and the force of blowing encreased by means of weights laid on the bellows, a much intenser heat would thus be produced by a pipe of a considerable opening at the end, by which the experiments must undoubtedly be carried

carried farther than with the common Blow-pipe.

§ 56. A traveller, who has ſeldom an opportunity of carrying many things along with him, may very well be contented with this Pocket-Laboratory, and its apparatus, which is ſufficient for moſt part of ſuch experiments as can be made on a journey. There are, however, other things very uſeful to have at hand on a journey, which ought to make a ſecond part of the Pocket-Laboratory, if the manner of travelling does not oppoſe it: this conſiſts of a little box including the different acids, and one or two matraſſes, in order to try the mineral bodies in liquid menſtrua, if required.

§ 57. Theſe acids are, the Acid of Nitre, of Vitriol, and of Common Salt. Moſt of the ſtones and earths are attacked, at leaſt in ſome degree, by the acids; but the calcareous are the eaſieſt of all to be diſſolved by them, which is accounted for by their calcareous properties. The acid of nitre is that which is moſt uſed in theſe experiments; it diſſolves the limeſtone, when pure, perfectly, with a violent efferveſcence, and the ſolution becomes clear: when the limeſtone enters into ſome other body, it is nevertheleſs diſcovered by this acid, through a greater or leſs efferveſcence in proportion to the quantity of the calcareous particles, unleſs there are ſo few as to be almoſt concealed from the acid by the heterogeneous ones. In this manner a calcareous body, which ſometimes nearly reſembles a ſili-

ceous

ceous or argillaceous one, may be known from these latter, without the help of the Blow-pipe, only by pouring one or two drops of this acid upon the subject; which is very convenient when there is no opportunity, nor time, of using this instrument.

§ 58. The Gypsa, which consist of lime and the vitriolic acid, (§ 18. 12.) are not in the least attacked by the acid of nitre, if they contain a sufficient quantity of their own acid, because the vitriolic acid has a stronger attraction to the lime, than the acid of nitre: but if the calcareous substance is not perfectly saturated with the acid of vitriol, then an effervescence arises with the acid of nitre, more or less in proportion to the want of the vitriolic acid. These circumstances are often very essential in distinguishing the *calcarea* and *gypsa* from one another.

§ 59. The acid of nitre is likewise necessary in trying the zeolites, of which some species have the singular effect to dissolve with effervescence in the abovementioned acid; and within a quarter of an hour, or even sometimes not until several hours after, to change the whole solution into a clear jelly, of so firm a consistence, that the glass, wherein it is contained, may be reversed, without its falling out.

§ 60. If any mineral body is tried in this menstruum, and only a small quantity is suspected to be dissolved, though it was impossible to distinguish it with the eye during the solution,

tion, it can be easily discovered by adding to it *ad saturitatem* a clear solution of the alcali, when the dissolved part will be precipitated, and fall to the bottom. For this purpose the *sal sodæ* (§ 20.) may be very useful.

§ 61. The acid of nitre will suffice for making experiments upon stones and earths; but if the experiments are to be extended to the metals, the other two acids (§ 57.) are also necessary. As the acids are very corrosive, they must not be kept in the ordinary Pocket-Laboratory, already described, for fear of spoiling the other apparatus, if the stoppers should happen not to fit exactly to the necks of the bottles, and any of the acid should be spilt.

The Sections 62. and 63. contained a description of the humid apparatus of the author. They are omitted, because a more extensive and compact apparatus is described in the appendix.

§ 64. Another instrument is likewise necessary to a complete Pocket-Laboratory, viz. a Washing-trough, in which the mineral bodies, and particularly the ores, may be separated from each other, and from the adherent rock, by means of water.

This trough is very common in laboratories, and is used of different sizes; but here only one is required of a moderate size, such as twelve inches and a half long, three inches broad at the one end, and one inch and a half at the other end, sloping down from the sides and the broad end to the bottom, where it is three quarters of an inch deep: I have given a figure of it in Plate 2. *fig.* 22*. of one *fourth* or *third* of the ufual fize. It is commonly made of wood, which ought to be chofen fmooth, hard, and compact, wherein are no pores in which the minute grains of the pounded matter may conceal themfelves.

It is to be obferved, that if any fuch matter is to be wafhed, as is fufpected to contain fome native metal, fuch as filver or gold; a trough fhould be procured for this purpofe, of a very fhallow flope; becaufe the minute particles of the native metal have then more power to affemble together at the broad end, and feparate from the other matter.

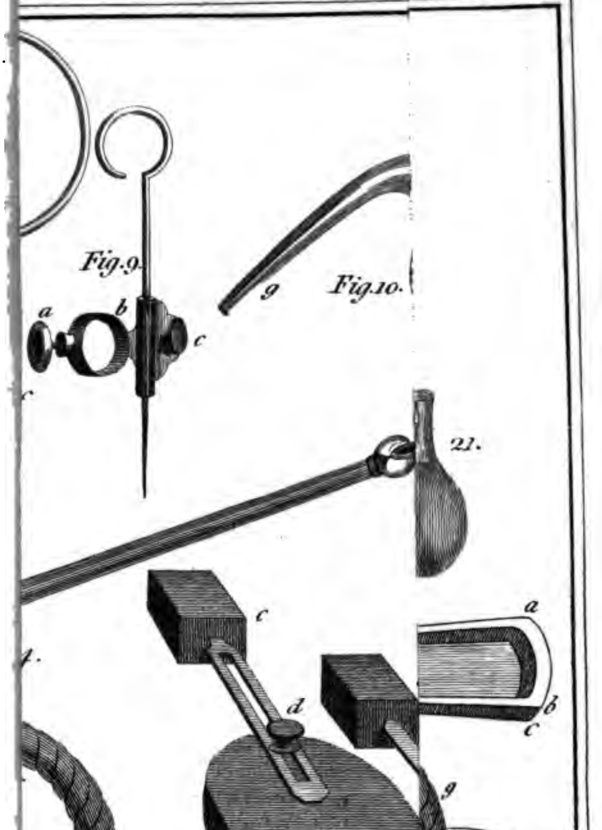
§ 65. The management of this trough, or the manner of wafhing, which I fuppofe to be known before, confifts in this. That when the matter is mixed with about three or four times its quantity of water in the trough, this is kept very loofe between two fingers of the left hand, and fome light ftrokes given on its broad end with the right, that it may move backwards and forwards, by which means the heavieft particles affemble at the broad and lower end, from which the lighter ones are to be feparated by inclining the trough and pouring a little water on them. By repeating this procefs, all fuch particles as are of the fame gravity may be collected together, and feparate from thofe of different gravity, provided they were before equally

* The trough which forms part of the apparatus defcribed in the Appendix, is of much fmaller dimenfions than here defcribed.

pounded;

pounded: though ſuch as are of a clayey nature, are often very difficult to ſeparate from the reſt, which, however, is of no great conſequence to a ſkilful and experienced waſher. The waſhing proceſs is very neceſſary, as there are often rich ores, and even native metals, found concealed in earths and ſand in ſuch minute particles, as not to be diſcovered by any other means.

PLATE II.



Jn. Lodge sc.

2. The great advantage of this kind of miniature essays is very obvious, and they are often much more advantageous, than experiments made at large in Chemical Laboratories. Mr. Engestrom has made several observations on this subject in the first sections of his treatise, to which may be here added, that by this method such phænomena are distinctly observed, as are necessarily lost in the large processes; for the assayer has under his eyes the progress of changes and transient phænomena caused by fire on every substance: which cannot be observed in a large furnace. Besides this circumstance, there are often specimens so rare, and so much esteemed by the owners, that the smallest pieces are not obtained but with difficulty, to determine their real contents; for as to their external appearances, no one can ever reasonably depend on them [a].

3. The names of those great Mineralogists, who have contrived and improved these travelling apparatus, need only be mentioned, to shew the decided advantages and great utility of such essays: these are the famous Andreas Swab, who first applied the blow-pipe to the examination of minerals, as Bergman observes;

[a] The external appearances, configurations, colours, and consistency of mineral bodies, are often promiscuously affixed to various fossils, and are of course so incapable of affording a knowlege of any individual substance of the fossil kind, that I can hardly form a notion how any reflecting person, not led away by a disposition for childish amusement, could ever attempt to mislead the public with a mineralogical system, grounded on such uncertain principles.

His

His celebrated ſcholar, our Author, Mr. Cronſtedt, and after him Rinman, Quiſt, Engeſtrom, Scheele, Gahn, and Bergman himſelf, all from Sweden, where the knowledge of mineralogy has been purſued with indefatigable zeal: and laſtly, the celebrated Mr. de Morveau of Dijon, who is now diſcloſing with the greateſt ſucceſs the abſtruſe receſſes of Modern Chemiſtry to the French nation.

4. The chief pieces and implements of the Pocket-Laboratories are repreſented in the two annexed plates. The firſt contains the whole *Dry Laboratory*, ſo called on account of its containing whatever is required to try all kinds of foſſils in the *dry way* by fire, without any of the *humid menſtruums*. It conſiſts of a box as large as an octavo book, lined with green velvet, and covered with black fiſh-ſkin. It is 8 ¼ inches long, 6 broad, and 1½ inches deep, outſide meaſure. The inſide is divided into different compartments, by thin partitions, which are continued to the bottom, in order to contain ſome other implements under thoſe repreſented in the quadrangular figure C. F. N. of the firſt plate, that are ſeen on opening the box.

5. D and Q are the two pieces that form the *blow-pipe*, which is repreſented entire at the bottom of the plate, marked by the ſame letters. This very uſeful inſtrument has been conſiderably improved of late in England. The mouth-piece *aa* is made of ivory, to avoid the diſagreeable ſenſation of having a piece of

metal a long time between the teeth and lips, which, if not of silver or gold, may be very noxious to the operator, a circumstance that has been hardly noticed before. The other improvements of this useful instrument are mentioned in the Note [b].

6. The

[b] It is rather extraordinary that the Blow-pipe has been considerably deficient in many respects, although it has been used from time immemorial by various artists, as *gold-smiths*, *jewellers*, *glass-blowers*, and many others; and even after having been adopted by many able and ingenious persons for mineralogical experiments. It is no matter of what metal the blow-pipe is made: brass is the most commonly used; but it may be made of *silver* or *gold*, according to the fancy of the owner, provided it possesses the good qualities required.

1. If the mouth-piece *a a* be made of a round form, it cannot be held for any length of time between the teeth and lips, to blow through it, without straining the muscles of the mouth, which produces a painful sensation. It must therefore have such an external figure, as to adapt itself accurately to the lateral angles of the lips, having a flattish oval form externally, with two opposite corners to fit those internal angles of the mouth, when it is held between the lips, as may be seen in that represented in the figure at the bottom of plate I.

2. The small globe *b b* is hollow, for receiving the moisture of the breath, and must be composed of two hemispheres, exactly screwing into one another in *b b*; the male-screw is to be in the lower part, and soldered on the crooked part *Q.* of the tube *Q D.* at such a distance, that the inside end of the crooked tube be even with the edge of the hemisphere, as represented by the pointed lines in the figure. But the upper hemisphere is to be soldered at the end of the straight tube *D.* By these means, the moisture arising from the breath falls into the hollow of the lower hemisphere, where it is collected round the upper inside end of the crooked part *Q*, of the blow-pipe, without being apt to fall into it.

3. The

6. The ſtream of air that is impelled by the blow-pipe, as ſeen in fig. 3. plate II. upon the flame, muſt be conſtant and even; and muſt laſt as long as the experiment continues to require it. This labour will fatigue the lungs, unleſs an equable and uninterrupted inſpiration can at the ſame time be continued. To ſucceed in this operation without inconvenience, ſome labour and practice are neceſſary. The whole artifice, however, conſiſts in this, *viz.* that, while the air is inſpired through the noſtrils, that part which is contained in the mouth be augmented at each expiration, and conſtantly forced out through the blow-pipe by the muſcular compreſſion of the cheeks. The compariſon of this operation to that of a

3. The ſmall nozles, or hollow conical tubes, adviſed by Meſſieurs Engeſtrom, Bergman, and others, are wrong in the principle; becauſe the wind that paſſes from the mouth through ſuch long cones, loſes its velocity by the lateral friction, as happens in hydraulic ſpouts, which, when formed in this manner, do never throw the fluid ſo far, as when the fluid paſſes through a hole of the ſame diameter, made in a thin plate of a little metallic cap that ſcrews at the end of the large pipe. It is on this account that the little cap *c* is employed, having a ſmall hole in the thin plate, which ſerves as a cover to it; and there are ſeveral of theſe little caps, with holes of ſmaller and larger ſizes, to be changed and applied, whenever a flame is required to be more or leſs ſtrong.

4. Another conveniency of theſe little caps is, that even in caſe any moiſture ſhould eſcape falling into the hemiſphere *b b*, and paſs along with the wind through the crooked pipe Q. it never can arrive at, nor obſtruct the little hole of the cap *c*, there being room enough under the hole in the inſide, where this moiſture muſt be ſtopped, till it is cleaned and wiped out.

double bellows is exactly true; but that of the piston in the air-pump, as some pretenders have hinted, is quite absurd.

7. Some persons may find this operation considerably difficult; but frequent trials will establish the habit, so that an uninterrupted stream of air can be emitted through the blow-pipe during one quarter of an hour, and even much longer, without any considerable fatigue, as I have experienced myself.

8. This stream of air is required to impel the flame upon the matter under examination. Too great a flame does not yield to the blast; and too small a one produces a weak effect. A slender candle should therefore be chosen, with a cotton wick. The burnt top must be cut off at such a length, that the remainder may be bent a little to near a right angle, as it appears by *a b* fig. 20. pl. II; and the same is represented also by the flame of fig. 3. The orifice *i* of the blow-pipe is to be held above, and near this bent part, in a perpendicular position to the wick, and then the air must be as regularly expelled, as possible. See § 13. p. 932.

9. The flame being thus forced sideways by the violence of the blast, exhibits two distinct appearances: the internal *e* (fig. 20. plate. II.) is conical, well defined, and of a blue colour; at the apex of this, the most violent degree of heat is excited: but the external flame *c d* is of a brownish, vague, and undetermined hue, which is deprived of its phlogiston by the surrounding atmosphere, and produces a much

less

lefs heat at its extremity than the interior bluifh flame. It is therefore the apex of this internal blue flame that muft be directed to the fubject which is required to be affayed; as it appears by *m* in fig. 2. pl. II.

10. But every affay is always to begin by the exterior flame, which muft be firft directed upon the mafs under examination: and when its efficacy is well known, then the interior blue flame is to be employed.

11. Particular care muft be taken to obferve, whether the matter *decrepitates*, *fplits*, *fwells*, *liquefies*, *boils*, *vegetates*, *changes colour*, *fmokes*, is *inflamed*, becomes *oily* or *magnetic*, &c. See § 18. p. 937. and the Notes.

12. The piece expofed to the flame fhould fcarcely ever exceed the bulk of a middle-fized grain of pepper; but it ought never to be fo fmall as not to be capable of being taken up by the tongs or forceps marked R pl. I. If it be too large, a part of it is neceffarily out of the focus, and muft cool both the fupport and the part immerfed in the blue apex of the flame, as is faid already at § 16. p. 934.

13. After the ore is roafted, it is to be pounded upon the fteel plate marked N. plate I. by the hammer E. the particles being prevented from being diffipated by the ring H, within which the pieces to be broken are to be put.

14. A fmall piece fhould always be added feparately to each of the fluxes, concerning which it muft be obferved, whether it diffolves

wholy, or only partially? whether this be effected with, or without effervescence? quickly, or slowly? whether the mass be divided into powder, or gradually and externally corroded? what colour the glass is tinged by, whether opake or pellucid? as has been already observed.

15. *C.* represents a wax-candle to be lighted for these trials, as being the most cleanly, although any other candle of tallow, or an oil-lamp, and still better a lamp with burning spirits of wine, may be made use of for the same purpose.

16. F. pl. I. is a round plate of brass, with a prong *d* in the middle, to serve as a candle-stick to hold the candle C. It has various concentrical grooves, to hold the solid different results of the experiments apart from each other. The space under the round plate C, which has the prong turned downwards, is filled by one or two small pieces of charcoal for serving as supports in the trials.

17. The three phials A. B. M. contain the three fluxes that are fit for these experiments; *viz.* the microcosmic or phosphoric *acid* is contained in that marked M. It is an acid already described, Sect. 164, and is partly saturated with *mineral*, and partly with *volatil* alkali, and loaded besides with much water, and a gelatinous fat. When exposed to the flame, upon the charcoal, it burns and foams violently, with a continual crackling noise, until the water and volatil alkali have flown off.

off. Afterwards it is less agitated, sending forth somewhat like black scoriæ, arising from the burnt gelatinous part. These are soon dispelled, and a pellucid sphærula, encompassed by a fine green cloud, is exhibited, being occasioned by the deflagration of the phosphorus arising from the extraction of the acid by means of the inflammable matter.

The clear globule which remains, upon the removal of the flame, continues longer soft than that formed by the borax, and therefore is more fit for the addition of the matter to be dissolved. The volatil alkali is soon expelled by the fire; therefore an excess of acid arises in what remains, which easily attracts moisture in a cool place.

18. The mineral alkali in the phial A, called otherwise *Sal Sodæ*, and described in Sect. 170, if fused upon the charcoal, melts superficially, with a cracking noise, penetrates the charcoal, and disappears. It is on this account that it is employed in the silver-spoon, marked P. on the outside of the Pl. I. but which is packed under D or E. If this spoon were made of gold, but of a smaller size, or of hammered platina, it would be more convenient.

19. This is one of the supports of the matters under examination; but a piece of charcoal cut in a form almost cubical, as represented in fig. 2. pl. II, is the most commonly used in many assays. Particles of ores that are very small and light are easily

3 carried

carried off by the blaſt of air. To prevent this accident, a ſmall cavity is to be hollowed in the charcoal, in which, being partly protected by another ſmaller piece of charcoal over it, they may be expoſed to the apex of the flame: and on ſome occaſions two pieces of charcoal are tied together with a binding-wire, that is packed up in the box near the hammer; and having made two hollows near the edges, a hard reducible ſubſtance may be there expoſed to the greateſt heat of the apex of the flame, as if it were in a reverbatory furnace. *See* § 18, *p.* 937, *of the preceeding* Treatiſe *of Mr. Engeſtrom.*

20. The phial marked B contains cryſtallized borax, already deſcribed Sect. 182. When expoſed to the flame upon the charcoal; at firſt it becomes opake, white, and wonderfully intumeſcent; throws out branches and various protuberances: but when the water is expelled, it is eaſily collected into a maſs, which, when well fuſed, yields a colourleſs bead, which retains its tranſparency even after cooling: ſee, however, note [*t*], p. 18. If calcined borax be employed, the clear ſphærula is more ſpeedily obtained. This is a neutral ſalt, and conſiſts of mineral alkali partially ſaturated with a peculiar acid, known by the name of *Sedative Salt* (Sect. 165): each of its principles is ſeparately fuſible, and each diſſolves a great number of other matters.

The habits of theſe ſalts, when expoſed to fire, being once known, it will be eaſy to underſtand

understand the differences occasioned by different additions.

21. G is a small link of hard steel, to try the hardness or softness of mineral substances; and also to strike fire for lighting the candle, when required.

22. K denotes two pieces of black flint, to serve as a touch-stone: for being rubbed with any metal; if it be gold, the marks will not be corroded by *aqua fortis*; and also to strike fire, when necessary, with the link G.

23. I is an artificial load-stone, properly armed with iron for the better preservation of its attractive power. It serves to discover the ferrugineous particles of any ore after it has been roasted, and powdered on the little square of steel N, within the ring H, Plate I, as mentioned N° 13.

24. L is a triple magnifier, which, differently combined, produces 7 magnifying powers, the better to distinguish the structure and metallic parts of ores, and the minute particles of native gold, whenever they contain that metal.

25. R is a pair of tongs for the easy handling the small pieces to be tried or examined; and to turn or take out from the melted fluxes the small buttons, or reguline products of the processes when hot.

26 S is a file, to try the hardness of stones and crystals, &c. This is put under the hammer E or elsewhere.

27. There are also put in the empty spaces, under the instruments, some pieces of dry agaric

ric or tinder, and small bits or splinters of wood, tiped with brimstone, to serve as matches for lighting the candle, and various other little articles of use in these experiments.

2d. THE HUMID LABORATORY, *viz.*

For performing Experiments in the *Humid Way*.

28. The case of this Laboratory is of the same form and dimensions as that of the *Dry Laboratory*, the depth only excepted, which is double, in order that the phials may stand upright, without being exposed to shake off their stoples. It has been thought quite unnecessary to add a plate engraved with the figure of this Laboratory, since every one knows well what must be the form of such a collection of phials put together. They contain the principal *acids*, *tests*, *precipitants*, and *re-agents*, both for examining mineral bodies by the *humid way*, and for analysing the various kinds of mineral waters. Those with *acids* and *corrosive solutions* have not only ground stoples; but also an external cap to each, ground over the stople, and secured downwards by a bit of wax between both, in order to confine the corrosive and volatil fluids within. But those which contain mild fluid liquors have not such external caps: and those with dry inoffensive substances are only stopped with cork.

29. Besides these phials, there are two smaller cylindrical ones, which serve to exhibit the changes of colour produced by some of the re-agents

re-agents in these analytical assays. There are also 2 or 3 small matrasses, to hold the substances with their solvents over the fire; a small glass funnel, for pouring the fluids; a little porcelane mortar, with its pestle; one or two crucibles of the same substance; a small wooden trough, to wash the ground ores; some glass sticks to stir up the fluid mixtures; and finally, pieces of paper tinged *red*, *yellow*, and *blue*, by the tinctures of *Fernanbuc wood* (commonly called *Brasil wood) Turmeric*, and *Lakmus*, thickened with a little starch.

30. The following list contains the names of the various *fluid tests* and *re-agents* that are necessary for these assays; and each phial is noted with the same ordinal number of the list, being distinctly cut with a point of a diamond on the outside surface of the phial. But their whole number being too large to be all contained in a small box, every one may give the preference to those he likes the best. They are the following:

1. Concentrated *vitriolic acid*, whose specific gravity may be expressed in the outside.
2. *Nitrous acid*, purified by the nitrous solution of silver.
3. Concentrated *marine acid*, with its specific gravity.
4. *Marine acid* dephlogisticated.
5. *Aqua Regia* for gold, viz. 2 Nit. and 1 Marine.
6. *Aqua Regia* for Platina, viz. half marine and half nitrous acid.

7. *Nitrous*

7. *Nitrous solution of silver.*

8. Nitrous solution of mercury, made in the cold.

9. Muriatic solution of Barytes.

10. Nitrous solution of *Lime.*

11. Muriatic solution of *Lime.*

12. *Mercury* in its metallic state.

13. Corrosive sublimate of *Mercury.*

14. White *arsenic.*

15. Nitrous solution of *silver.*

16. Nitrous solution of copper.

17. Acid of *Sugar.*

18. *Liquor probatorius vini.*

19. *Hepar Sulphuris.*

20. Oil of tartar *per deliquium.*

21. Salt of *Tartar.*

22. Caustic *vegetable alkali.*

23. *Pearl Ashes.*

24. Soap-makers Ley.

25. Common salt.

26. Vitriolated *argilla* (*alum.*)

27. Vitriol of iron [Copperas.]

28. Nitrous solution of *silver.*

29. Acetous solution of lead.

30. Acetous solution of Barytes.

31. Phlogisticated alkaly by the Prussian blue.

32. Lime-water.

33. Lime-water phlogisticated by the Prussian blue.

34. Caustic volatil alkali.

35. Mild volatil alkali (dry.)

36 Rectified spirit (alcohol).

37. Æther.

38. Spirituous tincture of galls.

N. B.

N. B. *There are some other* TESTS *to be mentioned in the Note* [*].

31. The method of applying the above tests of acids and re-agents may be seen in Bergman's Treatises of the *Analysis of Waters*, and of assaying by the *humid way*; in Kirwan's *Elements of Mineralogy*, in the *Elements of Chemistry* of Dijon, in the *Memoirs* of the same Academy, in Fourcroy's Lectures of Chemistry, &c.

3d. DESCRIPTION OF THE LAMP-FURNACE.

For Experiments, by the Humid *and* Dry Way, *represented in* Plate the Second.

32. This very curious and useful tho' small apparatus, is an improvement of that which was contrived by Mr. de Morveau, in consequence of the information he received from his friend, the President de Virly, who saw at Upsal how advantageously the late eminent Professor Bergman availed himself of this convenience for many analytical processes in miniature, by the use of very small glass vessels, about one inch diameter, and other implements of pro-

[*] The following *Tests* are very fit also for these assays, viz. 39. Spirituous solution of soap; 40. Sirup of violets; 41. Tincture of Litmus (*Lakmus* in Swedish); 42. Tincture of Brasil wood; 43. Tincture of turmeric (*terra emerita*); 44. Oil of olives; Oil of Linseed; 46. Oil of Turpentine; 47. Essential salt of wild-sorrel (*acetosellæ* vel *Oxalidis*); 48. *Hepar Sulphuris*; 49. Sugar of Lead; 50. Solution of Alum.

portional

portional ſize, for performing various chemical operations. *See* the Dijon Memoirs *for* 1783, *part* 1, *p*. 171.

33. There can be no doubt but that whenever theſe proceſſes are properly conducted, though in miniature, the lamp-furnace will prove amply ſufficient to perform, in a few minutes, and with very little expence, the various *ſolutions*, *digeſtions*, and *diſtillations*, which otherwiſe would require large *veſſels*, *ſtills*, *retorts*, *reverberatory furnaces*, &c. to aſcertain the component parts of natural bodies, though it is not always ſufficient to aſcertain their reſpective quantities. In this laſt caſe operations muſt be performed in great laboratories, and on a large ſcale, at a conſiderable expence. But the ſubſtances are ſometimes too valuable, as for inſtance, when precious ſtones are examined, and of courſe the laſt way never can be attempted in ſuch caſes.

34. Theſe ſmall proceſſes have likewiſe another advantage before noticed which cannot be obtained in works at large. It conſiſts in one's being able to obſerve the gradual progreſs of each operation, of eaſily retarding, or urging it, as it may require; and of aſcertaining at pleaſure each ſtep of every experiment, together with the phænomena attending the ſame.

35. The lamp-furnace is mounted in a ſmall parallelogram of mahogany, about 6 inches long and 4 wide, marked *fig*. 5, in plate 2. This is kept ſteady over the edge of a common table, by means of the metallic clamp *ww*, which

which is faſtened by the ſcrew *x*. The pillar *rs* is ſcrewed in a vertical poſition on the plate *s*, being about 10 inches high; the other is ſcrewed to the oppoſite corner, marked *p.k*, and is only 7 ½ inches long; both are compoſed of two halves, that ſcrew at *tt*, to be eaſily packed up with all the implements in a caſe covered with black fiſh-ſkin, and lined with green velvet, like the other laboratory already deſcribed.

36. The lamp *k* fig. 3 is ſupported on the plate *f*, which has a ring *l* that runs in the column *p k* and may be fixed by its ſcrew *l* at the required height. This lamp has 3 ſmall pipes of different ſizes to receive as many wicks of different thickneſs, and to be filled with ſpirit of wine. By a ſimilar method, a piece of charcoal is mounted and ſupported by the pliers, or little forceps ſcrewed to the arm *ac* fig. 1, which has all the motions requiſite for being fixed by means of proper ſcrews, at a proper diſtance from the flame of the wick *h*. The blow-pipe *fig*. 4. is, by a ſimilar mechaniſm, mounted on the ſmaller column *pq*, at ſuch a diſtance as to blow the flame *hi* to the piece of ore *m*, which is upon the charcoal *gf*.

36. Every thing being diſpoſed in this manner, the operator blows through the mouthpiece of the blow-pipe, *fig*. 4, and remains with his hands free to make the changes and alterations he may think proper.

N. B. The large round cavity *e* in the middle of the parallelogram, *fig*. 5, is to receive

 the

the lamp *k* fig. 3, when all the implements are packed up in their caſe of black fiſh-ſkin; and the cover of the lamp is repreſented by fig. 13.

37. But if the operator has the double bellows, *fig.* 14 and 15, he fixes them to the table by the braſs clamp *y*. He then unſcrews the blow-pipe at *zz*: joins the mouth *m* of the flexible tube to the hemiſphere *zz*, paſſing each orifice, through the leather tub *fig.* 12, and tying both ends with a waxed thin pack-thread. If he works with his foot on the pedal, the ſtring of which is ſeen hanging from the end of the bellows, fig. 15, (and is always up, on account of the weight *e*) then the air is abſorbed by the bellows fig. 15, from whence it is propelled by the motion of the foot on the pedal, to the bellow fig. 14, whoſe conſtant weight *r* drives it out through the flexible pipe *fig.* 11: it of courſe enters the curbed part *zzi* of the blow-pipe, and drives the flame on the piece *m* of the ore, that is to be examined upon the charcoal.

N. B. 1. This double bellows is packed up by itſelf in a mahogany caſe, about 9 inches long, 6 $\frac{1}{2}$ wide, and about 3 $\frac{1}{4}$ deep, outſide meaſure.

N. B. 2. The laſt blowing bellows, fig, 14, has an inſide valve, which opens, when the upper ſurface of it is at its greateſt height: in order to let the ſuperfluous air eſcape out, as it would otherwiſe iſſue with great velocity out of the tube *fig.* 11. and ſpoil the operation.

38. If

38. If the operator chuses to apply the *vital* or *dephlogisticated* air in his process, let him fill the glass-jar *b. fig.* 17, with this air; and put it within the tub marked by *a b z e*, filled with water, fastening the neck of the jar within by a cross-board *ed*, which has a hole in it for that purpose; then introducing the two ends of the flexible hollow tube (fig. 16) both to the mouth of the jar, and to the hole of the bellows, *fig.* 15; he opens the hole *m* of the jar, that was stopped with the stople *n*; the column of the water passes in through *m* and forces up the *vital air*, which enters the bellows, and of course, by the alternative motion of the pedal, passes through the end of the blowpipe, to urge the flame upon the piece of ore *m fig.* 2. on the charcoal *g* [*a*].

[*a*] But the *dephlogisticated air* may be also received at the same time, that it is produced, by tying the pipe, *fig.* 16, to the mouth an earthen retort, or of such a porcelain ware as that from Mr. Wedgwood's manufactory, or even of a glass retort well-coated, according to the method of Mr. Willis, described in the Transactions of the Society of Arts, vol. V. p. 96. This last consists in dissolving 2 ounces of borax in a pint of boiling water, and adding to the solution as much slacked lime as necessary to form a thin paste: this glass retort is to be covered all over with it, by means of a painter's brush, and then suffered to dry. It must then be covered with a thin paste made of *linseed oil* and *slacked lime*, except the neck that enters into the receiver. In two or three days it will dry of itself; and the retort will then bear the greatest fire, without cracking. Two ounces of good nitre, being urged in the retort, by a good fire on a chafing-dish, will afford about 7 or 800 ounce-measures of dephlogisticated air. See Priestley's Experiments on air, vol. III, (or VI.) of his Philos. Works, p. 295.

39. To make any other kind of chemical assays, the forceps of *fig.* 2, which supports the charcoal, is taken off, by unscrewing the screw *b*; the blow-pipe is also taken off, by loosening the screw *n*; the hoop *fig.* 8, is put in its place, where the metallic basin of *fig.* 19. is put filled with sand: the piece of *fig.* 9. is set on the other pillar *rs fig.* 1, to hold the matrass, fig. 18, upright or the receiver *fig.* 21, &c.

40. In the same manner the retort *fig.* 10, may be put in the sand-bath instead of the matrass, with its receiver fig. 21, which may be supported on a bit of cork or wood hollowed to its figure, and held by the plyers, instead of the charcoal *fig.* 2.

41. But if the operation is to be made in the naked fire, the neck of the retort *fig.* 10, being luted to the receiver, or balloon fig. 21, may be hanged by a little chain with its ring, over the flame, being suspended from the piece of *fig.* 8 or 9, screwed to either of the pillars as may be most convenient. Otherwise the receiver, fig. 21, may be supported by the round hoop of brass, fig. 9 or 8 screwed at a proper height to the pillar, *fig.* 1, tying round it some packthread, to defend the glass from the contact with the metallic support.

42. The piece of *fig.* 6 may be screwed by its collar and screw *ef* to any of the pillars; carrying with it the retort and its receiver, at proper distances, higher or nearer to the lamp, according as the flame is more or less violent.

43. It

43. It eaſily may be conceived that theſe implements afford all ſorts of conveniences for making any kind of ſmall operations and aſſays in miniature, provided the operator pays a proper attention to the diſpoſition requiſite for each proceſs or operation.

44. Every glaſs retort, receiver, matraſs, baſin, ſmall funnels, &c. was made by the lamp-workers, that blow beads, thermometers, and other ſmall glaſs inſtruments. N. B. The little funnels and ſyphons, to take off the waſhings from the ſubſtance that has boiled over the fire, were not engraved in *plate* the *ſecond*, to avoid crowding it, and embarraſſing the attention of the reader. Their figures are, however, ſo well known, that this omiſſion cannot produce any embarraſſment to a perſon of the leaſt ingenuity.

45. It is directed at N° 36, that the lamp *k. fig.* 3, is to be filled with ſpirit of wine, becauſe it gives no diſagreeable ſmell, and does not produce any fuliginous and diſagreeable cruſt on the veſſels as oil does; moreover, the ſpirit gives a dry flame, without ſmoke, and ſtronger than oil; beſides the ſpots and diſagreeable conſequences this laſt cauſes, if ſplit, &c. Mr. de Morveau adds, that the expence of ſpirit is quite inconſiderable, and that he performed in 8 or 10 minutes, with this apparatus, various diſſolutions, evaporations, and other proceſſes, which otherwiſe would have taken more than 3 hours, with the expence only of two or three halfpence for

the ſpirit of wine, whilſt the fuel of charcoal would have coſt near 10 or 11 pence.

46. But a very important circumſtance is, as Morveau obſerves likewiſe, that many philoſophers do not apply themſelves to chemical operations, for want of opportunity of having a laboratory to perform them, it requiring a proper room, and ſuitable expences of many large furnaces, retorts, crucibles, and numerous other implements, &c. whilſt theſe miniature laboratories may in great meaſure afford the ſame advantages, at leaſt to that degree of ſatisfaction ſufficient to aſcertain the contents and products of any ſubſtance that is ſubjected to trial; for with this ſimple apparatus a man of ſome abilities may, without any embaraſſement, in a very ſhort time, and with little expence, perform ſuch diſtillations as require a reverbatory furnace; all ſorts of proceſſes, digeſtions, and evaporations, which require a regular ſand heat; he may vary his experiments or trials, and multiply them to a great number of various performances, draw up his concluſions, and reaſon upon them, without loſs of time, without the hindrance of long preparations to work at large. And even when ſuch large works are to be performed, he may obſerve beforehand various phænomena of ſome ſubſtances, which being known in time, would otherwiſe impede the proceſſes at large, or make them fail abſolutely; and all this without the riſk of a conſiderable loſs, and without expoſing himſelf to a great fire, &c.

47. The results will be rarely, if ever, equivocal, especially if the operator is a man possessed of natural sagacity, and well acquainted with the general properties of the natural substances already known, If he directs his attention to the phænomena that happen in his experiments; and endeavours to use the proper means to obtain the knowledge he aims at, in order to destroy common prejudices, or to confirm those ideas and judgements of the objects he is to try and examine with his own eyes: in such a case he may depend upon it that his labours, in the corner of his study or cabinet, will never be, without producing some knowledge; since they will at least serve to direct him in those operations at large, which may be required to complete the proposed object, &c. *The Editor.*

APPENDIX II.

Containing various particulars of useful information to Mineralogical Enquirers.

1. *The Analysis of Earths and Stones by* Kirwan.

§ 1. The best general solvent for stones or earths seem to be *Aqua Regia*, composed of two parts *nitrous*, and one of the *marine acid.*

If the ſtone or earth effervefces ſtrongly with acids, no other preparation is requiſite than a ſeparation of ſuch parts as are viſibly heterogeneous, and pulverization; the ſolution is then eaſily performed in a digeſting heat, if requiſite. The undiſſolved reſiduum, if purely ſiliceous, will melt into a tranſparent glaſs with half its weight of *mineral alkali*; if not, it is ſtill compounded, and its ſoluble parts will yield to a reiterated digeſtion.

§. 2. If the ſtone does not effervefce, or eaſily diſſolve in acids, after pulverization and digeſtion, but leaves an inſoluble reſiduum evidently compounded, or but ſlightly altered, it will require to be pulverized and mixed with twice or thrice its weight of *mineral alkali*, and to be expoſed to a low red heat for one or two hours. Mica requires a mixture of four times its weight of *mineral alkali*; after which it is to be ſeparated from the alkali by lixiviation and filtration, waſhing it with diſtilled water until the water is abſolutely taſteleſs and precipitates no metallic ſolution.

§. 3. The powdered ſtone, thus edulcorated, is to be dried by heating it to redneſs, and then weighed, and 100 grains taken for ſubſequent experiments. It were better if ſtill more were uſed, but the analyſis would be more expenſive.

§ 4. The powder is next to be digeſted in 8 or 10 times its weight of *aqua regia*, in a boiling heat in a retort, to which a receiver is luted, and the digeſtion reiterated as long as any

any thing appears to be diſſolved by freſh portions of the acid. Mica was found to require 50 times its weight of *aqua regia* before it was entirely decompoſed, as the acid is ſo volatile as very ſoon to diſtill over. Oil of vitriol has the advantage of bearing a greater heat, diſſolving baroſelenite, and of acting more powerfully on argill than *aqua regia*; but a large retort muſt be uſed, for often towards the end it puffs and throws up the earth or ſtone, and carries it into the receiver; beſides, it does not ſufficiently act on calces of iron, if theſe be much dephlogiſticated. *Spirit of Nitre* affects them ſtill leſs: hence I often uſe oil of vitriol firſt, then what has been diſſolved I precipitate by a mild alkali; and re-diſſolve the precipitate in *aqua regia*. A perfect ſolution being thus effected, the reſiduum is to be well waſhed, and the waſhings added to the ſolution: the reſiduum, well dried and weighed, gives the weight of ſiliceous earth in the compound.

§ 5. The ſolution is next to be examined; which we will ſuppoſe to contain the four ſoluble earths, *calcareous*, *ponderous*, *magneſian*, and *argillaceous*, and alſo a *calx of iron*; it always contains an exceſs of acid, of which it is in great meaſure deprived for a conſiderable time, as both acids are very volatile: and indeed, of the *marine*, none remains but what is combined with the calx of iron, as the nitrous chaſes it from the earths. By getting rid of this exceſs of acid, leſs alkali will be required

 for

for the preceding precipitation, and leſs aerial acid ſet looſe which would retain much of the precipitate by re-diſſolving it; the ſolution ſhould then be evaporated to about half a pint.

§ 6. The ſolution being thus prepared, it is uſual to precipitate the calx of iron from it by the *Pruſſian alkali*; but to this method there are two objections: 1ſt, That the *ponderous earth*, if any, would alſo be precipitated and confounded in the *Pruſſian blue*: and 2d, That this precipitation, beſides being exceeding ſlow, ſeldom fails of leaving ſome iron ſtill in the ſolution, as the exceſs of the *Pruſſian alkali* which muſt neceſſarily be added, to be certain that all the iron is precipitated, never fails to re-diſſolve a portion of the *Pruſſian blue* which thus remains in the liquor, and cannot be got rid of. Hence the beſt method is as follows: firſt, prepare the Pruſſian alkali after the manner of Mr. *Bergman*, by digeſting and boiling a pure alkaline ſolution over Pruſſian blue, until the alkali no longer effervеſces with acids, nor precipitates a ſolution of nitrous ſelenite, or any other earth, except the barytes. I even make it a little ſtronger; for if it be barely ſaturated with the tinging matter, it ſoon ſpoils and precipitates other earths, the tinging matter evaporating. Next let it be examined how much of this alkali is neceſſary to precipitate one grain of *iron* from its ſolution in dilute *vitriolic* or *marine* acid, and mark this on the label of the

bottle

bottle that contains the alkali. Now we come to the application

§ 7. The ſolution of the earths being weighed, take 100 grains of it, and on theſe gradually pour the Pruſſian alkali (a portion of which is alſo previouſly weighed) until all the *iron*, or *ponderous earth* and *iron*, is precipitated; the weight of the alkali uſed, gives that of the *iron* contained in 100 grains of the ſolution; and the quantity contained in 100 grains of the ſolution gives that contained in the whole ſolution by the rule of proportion, from which the ponderous earth, if any be found in ſubſequent experiments, is to be deducted.

§ 8. The quantity of iron being thus found, the remainder of the ſolution is to be precipitated by aërated mineral alkali, and then boiled for half an hour, to expel as much as poſſible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in ſolution, but cubic nitre and a little common ſalt; when the precipitate has ſettled after one or two days reſt, the liquor is to be poured off, and the laſt portions taken up with a glaſs ſyringe. Diſtilled water is then to be added to the precipitate and boiled over it, and afterwards poured off, and taken up until it comes off taſteleſs.

§ 9. The precipitate being ſufficiently dried, is to be re-diſſolved in nitrous acid twice, and evaporated to dryneſs, then calcined for one hour in a white heat, and laſtly treated with about ſix or eight times its weight of diſtilled vinegar,

vinegar, in a heat of about 60 degrees, for one or two hours; by this means the *ponderous*, *calcareous*, and *magnesian* earths will be extracted and separated from the argill and calx of iron, which will remain undissolved.

§ 10. Of this acetous solution 100 grains should be taken and examined with the Prussian alkali: if any part be precipitated, it is ponderous earth, and by heating it to redness its weight may be known: or still better by a previous experiment, determining the quantity requisite to precipitate one grain of acetous baroselenites, and by the rule of proportion the quantity of it in the whole solution may be found.

§ 11. The remainder of the acetous solution is to be evaporated to dryness, and heated white in a clean polished iron crucible for two hours, then weighed and thrown into hot distilled water; the calcareous earth (if any) will be dissolved in a sufficient quantity of this water, of which an ounce can scarcely dissolve one grain, so that frequent affusions of hot water may be requisite; the magnesia will remain undissolved, and is to be dried and weighed; its weight gives that of the pure calcareous earth, from which that of the ponderous (if any) is to be deducted; the lime water may also be precipitated by an aerated alkali.

§ 12. Lastly the argill and calx of iron, which remained undissolved by the acetous acid, are to be heated slightly, to prevent their cohering and reiteratedly boiled in dephlogisticated nitrous acid to dryneſs, and finally diſſolved in that acid, which will then take up only the argill, which may be precipitated, dried, and weighed; though indeed this troubleſome operation may be unneceſſary, as the weight of the martial part being known by the experiment with the Pruſſian alkali, that of the argill is known of courſe, when only the two remain. This is even better, as the calx always increaſes in weight by theſe operations.

§ 13. Beſides this general method, ſome others may be uſed in particular caſes. Thus *to diſcover a ſmall proportion of argill, or magneſia, in a ſolution of a large quantity of calcareous earth*, cauſtic volatile alkali may be applied, which will precipitate the argill or magneſia, if any be, but not the calcareous earth. Diſtilled vinegar, applied to the precipitate, will diſcover whether it be argill or magneſia.

§ 14. 2dly, *A minute portion of calcareous or ponderous earth, in a ſolution of argill or magneſia*, may be diſcovered by the vitriolic acid, which precipitates the calcareous and ponderous; the ſolution ſhould be dilute, elſe the argill alſo would be precipitated. If there be not an exceſs of acid, the ſaccharine acid is ſtill a nicer teſt of calcareous earth. 100 grains of gypſum contains about 32 of calcareous earth; 100 grains of baroſelenite contains 84 of ponderous earth; 100 grains of ſaccharine ſelenite contains

tains ·45 of calcareous earth; the insolubility of baroselenite in 500 times its weight of boiling water sufficiently distinguishes it. From these *data* the quantities are easily investigated.

§ 15. 3dly, *A minute proportion of argill in a large quantity of magnesia* may be discovered either by precipitating the whole and treating it with distilled vinegar, or by heating the solution nearly to ebullition, and adding more aërated magnesia until the solution is perfectly neutral, which it never is when argill is contained in it, as this requires an excess of acid to keep it in solution. By this means the argill is precipitated in the state of embryon alum which contains about half its weight of argill (or for greater exactness it may be decomposed by boiling it in volatil alkali). After the precipitation, the solution should be largely diluted, as the Epsom salt, which remained in solution while hot, would precipitate when cold, and mix with the embryon alum.

§ 16. 4thly, *A minute portion of magnesia in a large quantity of argill* is best separated by precipitating the whole, and treating the precipitate with distilled vinegar.

§ 17. Lastly, *Calcareous earth and Barytes* are separated either by precipitating the barytes by the Prussian alkali, or the calcareous by a caustic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the solution to a small compass, pouring off the liquor, and treating the dried precipitate with

500

500 times its weight of boiling water; what remains undiſſolved is baroſelenite.

II. *Deſcription of a new Inſtrument for finding* ſpecific gravities, *by* Nicholſon.

Since mineralogiſts often want to know the ſpecific gravity of various *ſtones*, and other *ores*; as well as of *fluid acids* and other liquors; a deſcription of a new inſtrument of this kind may be acceptable in this place, as it is very eaſy and portable. It was invented by Mr. W. Nicholſon, and is inſerted in the ſecond vol. of *Memoirs*, publiſhed by the *Philoſophical Society of Mancheſter*, in 1785, from whence the following extract may be ſufficient to form an idea of its advantages.

2. This inſtrument is repreſented by *fig.* 23, Plate 2, and it conſiſts in a thin hollow ball A. of copper, of the ſize of a common hen's egg, with a ſmall baſin *e.* like a funnel, ſupported by a thin wire *db.* on the top, and a ſmall baſin *gh.* at the bottom, which muſt be ſo heavy, that on loading the upper one *e* with 1000 grains (or half grains), when the inſtrument is immerſed in diſtilled water, its ſurface be exactly at *cc.* [*g*].

3. Suppoſe

(*g*) This ball muſt be turned in the lathe very thin, and be tight againſt water and air. On the top is a little ſhoulder *b* with ſuch a hole, as to receive pretty tight the body of a

3. Suppose you want to know the specific gravity of the body *x*, which must be of course less than 1000 *half grains*. On putting it in the upper basin *e*, so many units, or half grains, must be added in the same basin, as to make it sink, until the surface of the water comes to the white circle of the stem. It is evident that the weight of *x* is equal to the remaining unities, after the additional weight in the basin *e* is substracted from 1000; thus, for example, if there were added to *e* 280 unities; in this case the weight of *x* is 720: for + 1000 — 280 = 720 [*b*].

4. Now

a common sowing needle whose point and eye have been broken off; this is to have a visible mark in the middle, for which purpose it is first rendered blue by heat; and by rubbing it with a thin plate of brass crossways, weted with oil and fine emery, a small circle of the white metal will be there sensibly formed round it.

[*b*] *N. B.* 1. The water must be the same in every experiment, and must have the same temperature; the 60 degree of Fahrenheit, is the most convenient, as it is commonly found in a temperate room. A small thermometer therefore must be always provided for the use of the instrument: 2. And if the instrument itself requires a greater or less number of grains to sink it to the mark at any given temperature; it will serve at any time to shew whether the density of the water is the same, of that of distilled water, &c. 3. Great care must also be taken that no bubble of air be sticking to the body *x*, or to the under basin during the experiment, or else the result will be erroneous. 4. The handling of every part must be made by a pair of dry tongs, such as those of fig. 7. 5. Finally, if the water cannot be had distilled, nor even rain water, which is nearly the same; then the body *x* that is kept with the instrument must be examined in this water, and a new body being also examined,

4. Now let *x* be put in the lower bafin *gh*, leaving the other unities as before in the bafin *e*; then add as many of the fame unities to *e*, until the furface of the water be again at *cc*. This additional number fhews exactly the quantity of water that is difplaced by the body *x*. Suppofe it to be 60 unities: divide now the whole weight (=720) by this known bulk of water equal to it, viz. 60, and the fpecific gravity of *x* will be fhown by the quotient; viz. $\frac{720}{60} = 12$: which denotes, that the body *x* is 12 times heavier than an equal bulk of diftilled water.

5. As for afcertaining the fpecific gravities of *acids*, or other *fluid matters*, the fame method, already explained in the Notes to pages 612 and 613, may be equally applied to this new inftrument.

6. Or elfe, take a very fmall glafs phial, with a ground ftopple, and afcertain, when filled with water, its fpecific gravity by the above method; afterwards fill it exactly with the *acid*, or *fluid fubftance*, and determine by the fame method the fpecific gravity of both; deduct that of the phial alone, from the fecond laftly afcertained; and the remainder will be the fpecific gravity of the *acid* or *fluid* you tried the laft.

examined, the refpective fpecific gravities forming a compound with the weight of each body, a proportional refult may be found to determine the true fpecific gravity of the new body relatively to diftilled water. The obfervations in this note apply univerfally to all hydroftatical experiments made with any inftrument whatever.

III. *An eaſy and very accurate Method of making* ORIGINAL WEIGHTS. *By the* EDITOR.

7. A very great difficulty, for the above operations of finding ſpecific gravities, conſiſts in having a very exact ſet of weights. I have diſcovered a new method, which I publiſhed ſeven years ago in the *Journal de Phyſique*, for January 1781, page 43. It is the eaſieſt, the cheapeſt, and the moſt exact, of any that ever was practiſed before; notwithſtanding which, I often hear repeated complaints of experimental operators, who ſtill adhere to the old and tedious method, without taking notice of the new one. This laſt conſiſts on the following particulars.

8. *Firſt*, Let a pair of ſcales with a very nice beam be provided, within a lanthorn, with glaſs panes on every ſide, having two ſmall lateral doors that may be open, facing each of the ſcales. Theſe are the only openings to be uſed, the front one being always ſhut during the operations, on account of the breath of the operator, which otherwiſe would diſturb the balances. As to the qualities of the beam, the eſſential one is, that it be conſtantly true, and ſenſible to the ſmalleſt weight, every time it is tried; for there are many falſe or unſkilfully conſtructed beams, that often vary in giving the equipoiſe of the very ſame things. But as to the length of the arms, from the point of

of ſuſpenſion, it is no matter whether they are accurately equal or not.

Each ſcale muſt have a looſe ſmall baſin very light, to convey the things and weights in every operation.

9. *Secondly*, Prepare a good quantity of equal *unities*, for which a good method will be given by and by. Take a piece of *tinſel*, which is the thineſt plate of *lattin* (or *latten foil*, as Watſon calls it), ſuch as the taſſel and button-maſters employ in their work, but this muſt not be varniſhed any ways; which may be eaſily known by wetting it with water, for it will then dilute the coloured ſubſtance of the iſinglaſs with which it was varniſhed. If ſo, let it lie in hot water about twenty minutes; then waſh and wipe it. 4*thly*, Cut out twelve or more triangular pieces of the tinſel, beginning with a very ſmall one about the $\frac{1}{10}$ part of an inch, and increaſing the others little by little, till the largeſt is the ſize of an inch; and fold one of the corners of each upwards, that it may eaſily be taken up with the tongs of Fig. 7, Plate II. 5*thly*, You ſhould be provided with a ſet of very ſmall punchers of ſteel, containing the ten numerical figures, from 0 to 9 incluſively. Theſe are ſold ready made at the tool-ſhops, and coſt only two or three ſhillings. 6*thly*, Stamp your ſmaller triangle with No. 1. the ſecond in ſize with No. 2. and ſo on. This being done, cut a ſmall parallelogram a little heavier than your greater triangle, which you will mark with No. 13 or 15, and

cut others till they are the ſize of an inch, taking care to bend one corner of each.

10. Take afterwards a piece of the common lattin ſheet, which is conſiderably thicker than the tinſel, and do the ſame as before, beginning with a triangle a little heavier than the bigeſt parallelogram of tinſel, and marking it with the following numbers of 24 or 30, and ſo on as before. Afterwards do the ſame with braſs plate whoſe thickneſs may be afterwards increaſed as far as your beam will be able to bear without bending or ſpoiling its axis. Then ſhut up each ſet of weights ſeparately in ſmall caſes or boxes, and ſtamp upon the outſide of each the two extreme numbers (the higheſt and the loweſt) of the pieces or weights there contained, in order to know afterwards in what box are the weights you may want.

11. Take now a very thin wire of gilt ſilver or metal, ſuch as the fineſt employed by the wire-drawers, before it be flattened in the mill, for covering the ſilk threads; wind it up very cloſely upon two wires as thick as large pins, *viz.* about $\frac{1}{20}$ of an inch thick; then cut the whole cover of thin wire lengthways, with the point of a ſharp penknife, running it between the two thick wires, and collect all the ſmall oval rings to ſerve as ſo many *unities*, which you may keep in a ſmall box by themſelves; and the ſame muſt be done with each dozen of the triangles and parallelograms, according to their numeros, the firſt and laſt of which ſhould be marked on the outſide, to find it eaſily

eaſily when neceſſary, as was already obſerved in the laſt article.

12. *N.B.* You muſt form your unities of ſuch wire, that each be very ſenſibly felt by your own ſcales; otherwiſe your labour would be worth nothing; for you cannot go farther than the leaſt quantity of weight that your ſcales are able to indicate.

Now, as to the practical method of making the niceſt operations with weights, it conſiſts in making uſe only of the right-hand baſin, both for the things to be examined, and for the weights; employing the left-hand ſcale only for counterpoiſing each weight as follows.

13. Make your ſcales very even, by putting ſome bits of braſs or wire on the left-hand one, both having one ſmall movable baſin as aboveſaid. When the equilibrium is perfect, take with the tongs (fig. 7.) the right-hand baſin; put therein your ſmalleſt triangle No. 1, and putting it again in the ſame ſcale, counterpoiſe it in the left-hand with any ſmall bits of metal.

14. *N.B.* Try whether it is right, by adding one *unity* more, and taking off another afterwards: obſerving whether the beam moves on each ſide. This proof is the moſt eſſential of all. After this, take out the right-hand baſin, and the triangle: put in as many *rings* or unities (No. 11.) as will counterpoiſe the other ſcale on the left-hand; and try by the above method of *adding* and *ſubſtracting* one unity, that it is right.

After-

Afterwards the ſame muſt be obſerved with each weight. Form then a liſt of your weights in a ſheet of paper divided into three columns; the firſt on the left-hand intitled *Pieces*; the ſecond *Quantity*; and the third *Accuracy*. Fill up the firſt column with a continued ſeries of numbers from 1 to 100, or to ſuch other number as you pleaſe, Then write facing each number the total of *unities* anſwering to each piece marked with the ſame; and in the third column write the *unity*, which being added or ſubſtracted, makes the balance turn one way or other. By this laſt column it will appear how nice your weights are, and how delicate are your balances [*i*].

15. By this method you may uſe as many ſets of weights as to come to hundreds and more pounds, with this particular advantage, which no one elſe ever obtained before, *viz.* of having a thorough conviction that each of your ounces or pounds cannot be deficient within or beyond one of your unities, if to ſuch an accuracy you have carried your performance [*k*].

16.

[*i*] You are to employ, in each operation, the ſame pieces whoſe weight is already aſcertained, adding only three or four of your unities, mentioned No. 11; and by ſo doing you will have the certainty that each is exact to a leſs error than one of the ſaid unities, which is no more than $\frac{1}{1000}$ or $\frac{1}{300}$ of a grain weight.

[*k*] This propoſition is ſelf-evident, and of courſe does not require any demonſtration. But it is proper to obſerve, to ſuch as are unacquainted with the ſubject, that very large weights cannot be aſcertained totally, with ſuch a nicety as is here mentioned. The only obſtacle, which indeed is inſuperable,

3

16. Laſtly, to know the relative weight of the Troy kind, get one of the moſt authentic *penny-weights* from the Mint in the Tower, or from the King's Aſſayer; weigh it with your weights, and you will immediately know how many of your unities make a penny-weight of England, or a *gros* of France, and ſo on of any other country whatever; ſo that by a ſimple calculation you will poſſeſs an original and univerſal ſcale for all kinds of weights.

THE EDITOR.

N. B. *All the above inſtruments,* viz. *the two* Pocket Laboratories, *the* Lamp-furnace, *the new inſtrument for* ſpecific gravities, *and the ſets of new weights, are ſold at moderate prices, by* William Brown, *Bookſeller, at the corner of* Eſſex-ſtreet, *in the* Strand, *near* Temple-Bar, London.

ſuperable, consiſts in this, *viz.* that among all the known ſubſtances to which the human power can have recourſe, there are none ſo hard and unalterable as to form a beam, whoſe axis or points of ſuſpenſion, when loaded with the preſſure of *twice twelve ounces,* (two pounds weight,) ſhall not be ſo blunted or altered as to be incapable of yielding to the gravitating power of $\frac{1}{600}$ of a grain. From whence it is equally ſelf-evident, that no weight whatever can be aſcertained at once to a much greater accuracy than to the leaſt ſmall quantity, which being added or ſubſtracted, will cauſe ſome ſenſible difference in its perfect equilibrium.

THE END.

AN

ALPHABETICAL TABLE

OF THE

CONTENTS.

The Numbers indicate the Pages; the three Letters *a. b. c.* mean the *top*, *middle*, and *bottom* of each; and *n* means to be in the *Notes*.

A.

Cats-

Cat's-

D.

Diamonds,

Glaſs-

H.

Hammites,

Red

Mercury

2

Osteocola,

Platine.

Q.

Sal

Volatil

THE END.